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Screening and patient selection for bone-anchored limb implantation and rehabilitation: what makes a good candidate?

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Abstract Osseointegration of a bone-anchored limb (BAL) is an emerging rehabilitation technique that offers significant advantages over traditional socket prostheses. By addressing functional limitations and recurrent cutaneous complications, BAL systems have shown an 82%–90% increase in daily prosthesis use among patients, who also report improvements in functional ability, balance, comfort, and overall quality of life. Despite these benefits, the process of patient selection for BAL remains underdeveloped, with evidence-based guidelines still in their infancy. This article aims to propose a workflow for patient selection and screening in BAL osseointegration, leveraging the current literature, interdisciplinary clinical experience, and established models. A comprehensive evaluation process is suggested that incorporates anatomical, physiological, psychological, and lifestyle factors. These include radiological evaluation, amputation history, prosthetic component assessment, laboratory tests, psychiatric history, cognitive assessments, and considerations of home safety and postoperative care. The evaluation should ideally be conducted by an interdisciplinary team to ensure a balanced consideration of risks and benefits for each candidate. As the understanding of BAL osseointegration advances, it is expected that patient indications will expand and contraindications will be more clearly defined. The proposed workflow aims to standardize patient selection, thereby optimizing surgical outcomes and rehabilitation processes. This approach is essential for maximizing the benefits of BAL systems while ensuring patient safety and improving long-term rehabilitation outcomes.

1. Introduction

Osseointegration of a bone-anchored limb (BAL) involves the surgical insertion of a metal implant into the residual bone, facilitating a direct interface between the bone and a load-bearing prosthetic limb through a transcutaneous connector that is externalized through a rounded skin penetration aperture (SPA) in individuals with limb loss.[1,2] This technique has emerged as an alternative rehabilitation option for amputees, offering distinct advantages over traditional socket prostheses by addressing functional limitations and recurrent cutaneous complications, resulting in an 82%–90% increase in daily prosthesis use.[3,4]

Since the initial BAL procedure in Sweden in 1990,[1] different implant designs, surgical techniques, and rehabilitation protocols have been developed, each with its own strengths and limitations.[2] Three fundamental osseointegration implant styles including threaded, press-fit, and preloaded compression implants, each with specific associated surgical techniques, have been developed.[3–7] Each implant type has distinct anatomical and

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physiological requirements for patient selection, despite sharing similar fundamental eligibility criteria.[3–7] Despite the potential benefits of these BAL systems, the evidence supporting patient selection and screening remains in its infancy and is not yet definitive. As the understanding of scientific research and clinical experience continues to evolve, it is anticipated that the indications for BAL will expand while contraindications will become more refined.

Given the lack of consensus on BAL indications, there is a pressing need for a standardized screening and patient selection workflow independent of the selected implant type and surgical technique. This article aims to propose such a workflow, informed by the current literature, the collective experience of an interdisciplinary team, and established programs, to enhance the efficacy and safety of BAL implantation and rehabilitation. Fundamental to patient selection is the thorough assessment of 4 key components: anatomical, physiological, psychological, and lifestyle evaluation.

2. Goals of Individuals With Limb Loss Pursuing Bone-Anchored Limbs

When problems with traditional socket-mounted prostheses continue to affect a lower limb amputee's functional outcomes and overall quality of life, many of them consider BAL surgery. When evaluating patient goals for BAL implantation, it is important to assure that patient goals and expectations are congruent with expected outcomes, based on current literature and/or clinical experience. While socket-mounted prostheses remain the standard for mobility after amputation,[2] more than half of the patients using socket prostheses are functionally limited as a result of a variety of factors, including common skin breakdown/ulceration,[3] frequent refitting,[4] residual limb pain/deformity/size fluctuation,[5,6] and general lack of confidence with ambulation.[7] In addition, variable pain phenotypes such as phantom pain, residual limb pain, and/or body pain can affect up to 95% of amputees.[8,9] The higher energy requirements of socket prostheses compared with a nonamputated limb contribute to an increased risk of falls. Studies[10,11] revealed that socket prosthesis users frequently experience falls, which can negatively affect their social participation. BALs can reduce energy expenditure and reduce the risk of falls. These benefits help amputees resume daily activities and social engagement, thereby improving their overall quality of life.[12]

Furthermore, BAL users report better functional ability,[13,14] improved balance and balance confidence,[15] better sitting comfort, larger amputated limb hip range of motion,[16] fewer contractures, easier donning and doffing,[16,17] perception of mechanical forces through the BAL (coined "osseoperception"),[18] and overall better quality of life (QoL), compared with their baseline status using a socket prosthesis.[17,19–23] This improved QoL is thought to result from a variety of secondary variables including decreased prosthetic/socket complications, increased functionality/mobility, and reduced joint pain.[14–17,19–26]

3. Screening and Selection Workflow for Bone-Anchored Limb Candidates

As of 2024, the existing evidence-based literature delineates a specific cohort of ideal candidates for BAL, primarily individuals with limb loss who experience intolerance toward socket-based prostheses. A multifaceted evaluation process is required to determine whether a patient is suitable for osseointegration of a BAL and associated rehabilitation. We present a framework for clinicians to follow to determine patient selection, including anatomical, physiological, psychological, and lifestyle considerations. The framework represents consensus of experienced BAL clinicians from programs across the country. Each of these categories plays a crucial role in ensuring that the patient is not only a suitable candidate for the procedure but also likely to benefit from it in the long term (Fig. 1).

4. Anatomical Considerations

4.1. Screening

A radiological examination, a detailed amputation history, and physical examination are essential for assessing the anatomical suitability of BAL candidates.

4.1.1. Radiological Tests. Calibrated radiographs visualize the residual limb to ensure that it is skeletally mature and has sufficient bone mass, length, and cortical thickness to support the BAL.[17,25,27,28] Computed tomography (CT) scans assess the quality and diameter of the medullary canal, which are critical for surgical planning and confirmation of sufficient bone mass for integration.[29–32] The integrity of the adjacent joints will also be assessed to ensure that they can withstand the increased postoperative load and the need for potential arthroplasty in the future. Likelihood of adjacent joint arthroplasty in the future must be factored into surgical planning and informed consent process. Adequate bone stock is required, as measured by the residual length and the cortical thickness at 4 points (anterior, posterior, lateral, and medial) at the expected resection plane, with an average cortical thickness of at least 2 mm required for implant stability[22,33,34] (Fig. 2). Depending on the clinical findings, additional imaging procedures such as MRI or bone scans may be needed.

4.1.2. Amputation, Surgical, and Prosthetics Use History. Assessing the patient's amputation history, including the primary cause, laterality, and amputation level (eg, upper vs. lower limb and transfemoral or transtibial), is necessary for screening and surgical planning. Previous surgeries, such as retained hardware in the residual limb, should be documented, as it may affect surgical planning. In addition, attention should be given to any history of secondary complications, previous infection, phantom limb pain, neuromas, joint contractures, and the disuse or overuse of contralateral limbs. Evaluating the patient's current prosthetics use, mobility, and difficulties with socket fit or donning/doffing is essential for optimizing outcomes.

4.1.3. Physical Examination. During the physical examination, priority should be given to inspection of residual limb soft tissue, including swelling, atrophy, open wounds, contractures, and scar tissue (Fig. 3). In addition, assessment of motor, sensory, and vascular functions and joint range of motion in both the residual limb and sound limbs is crucial to evaluate potential for successful healing and rehabilitation. A thorough assessment of the prosthetic componentry's functionality is essential during the screening phase before BAL surgery, conducted by a qualified prosthetist. This evaluation ensures that the prosthetic components meet the patient's specific needs and will perform effectively after BAL surgery. Early interdisciplinary assessment is essential

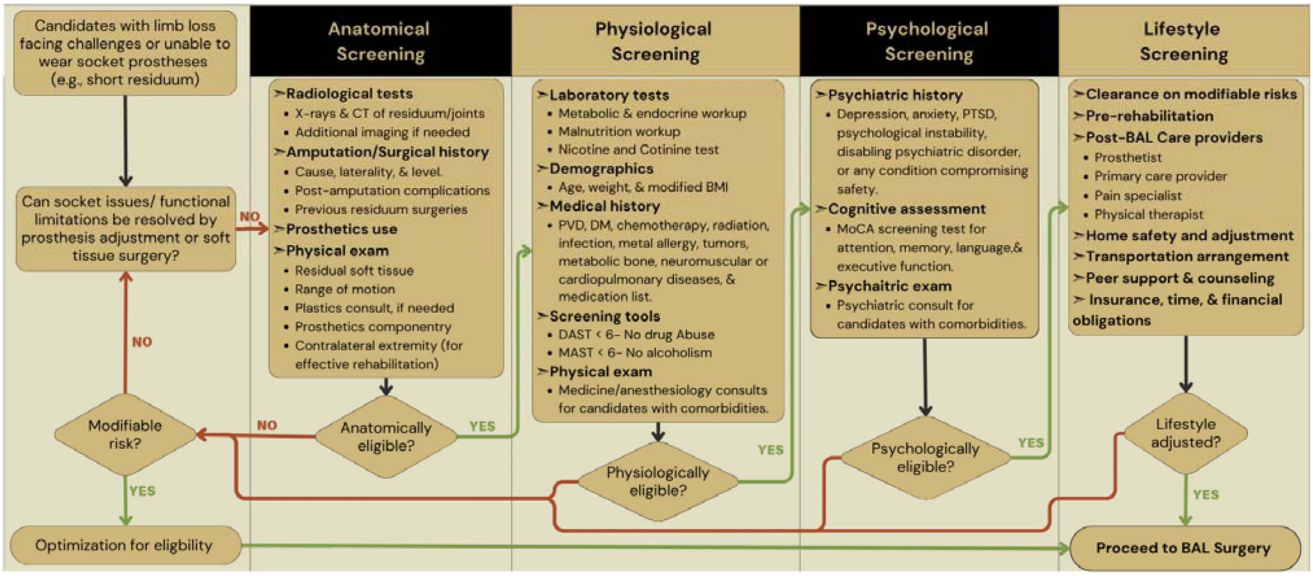

Figure 1. Screening and selection workflow for bone-anchored limb candidates.

to ensure that socket-related discomfort or functional limitations cannot be resolved by adjusting the socket prosthesis or by surgical revision of the soft-tissue envelope. Preoperative planning should also include decisions about the need for skin flaps or grafts and consider the simultaneous performance of implant placement, management of nerves/neuromas, and soft-tissue surgery to improve the postoperative stability of the soft-tissue envelope especially at the skin–implant interface, thereby minimizing postoperative irritation, infection, and reoperation rates.

4.2. Eligibility

Ideal candidates are skeletally mature individuals,[12,17,28,31,33,35–37] with transfemoral,[12,17,22,25,27,28,30,33–39] transtibial,[25,38] or transhumeral amputations,[40] whether unilateral or bilateral. They should ideally have normal residual skeletal anatomy[17,28,33] with sufficient residual bone dimensions per implant type[30,31,39] and an adequate myofascial flap to allow for circumferential contact with the implanted device.[41] The primary cause of amputation may be congenital,[14,25,34] trauma,[14,25,34]

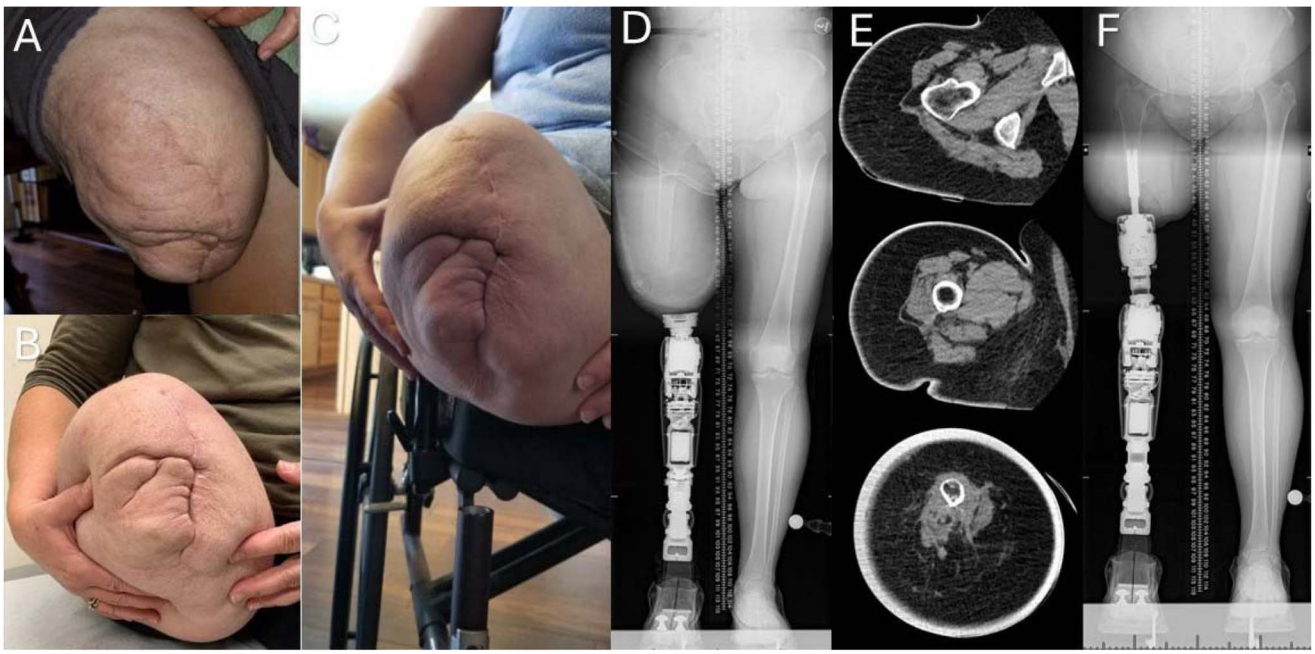

Figure 2. (A–C) Routine physical examination of the residual limb and adjacent joint in a patient with unilateral transfemoral amputation. (D) Radiographs (standing hip-to-ankle X-ray with prosthesis) of a patient with unilateral transfemoral amputation using a socket prosthesis. (E) Axial CT scan of the right transfemoral residual bone assessing intramedullary canal integrity and diameter. (F) Radiographs (standing hip-to-ankle X-ray with an OPRA implant and BAL prosthesis) showing a unilateral osseointegrated OPRA implant in the residual femur attached to a prosthetic leg.

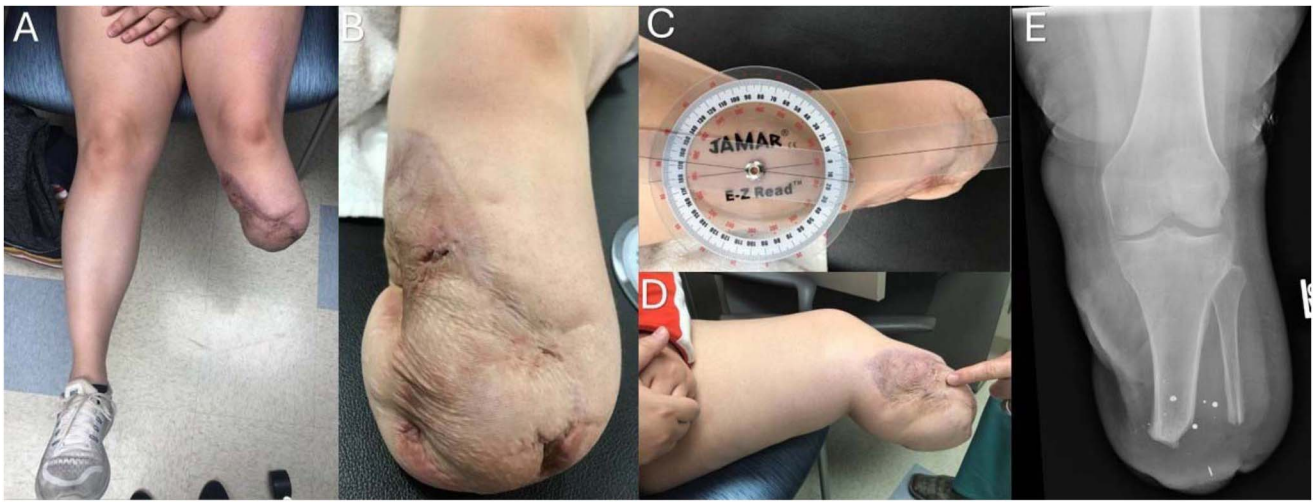

Figure 3. (A–D) Routine physical examination of the residual limb and adjacent joint in a patient with unilateral transtibial amputation with complex soft-tissue envelope. (E) Supine radiograph of the residual left tibia and fibula with retained foreign bodies from traumatic injury.

tumor resection,[14,25,34] or stable vascular disease.[25] In addition, these candidates often have a history of using a socket prosthesis and facing considerable rehabilitation challenges and documented failed attempts.[12,17,22,25,27,28,30,33–39] The amputee may be suffering from 1 or more of the following conditions: recurrent skin infections and/or ulcerations in the socket contact area; a short residual limb preventing effective socket prosthetics use; volume fluctuation of the residual limb impeding socket prosthetics use; extensive skin grafting or soft-tissue scarring; socket retention difficulties due to excessive perspiration; an unsatisfactory attempt with socket-mounted prosthetic rehabilitation; or pain related to socket use.[12,17,22,25,27,28,30,33–39] Nevertheless, there are cases where BAL might be initially contemplated as a primary option, particularly for patients with chronic pain or extremity dysfunction electing to undergo amputation with primary BAL reconstruction because of insufficient or compromised residuum that is incapable of sustaining a socket-based prosthesis. Practical considerations for primary BAL implantation should be made when an amputee has received a BAL on 1 lower extremity and then requires subsequent amputation on the contralateral extremity. To date, there is a paucity of research on primary BAL implantation.[38]

General contraindications to BAL include insufficient myofascial flaps, severe osteoporosis (T-score ≤ -2.5),[38] systemic osteopenia, and bone deformity.[35] Implant-specific requirements for residual bone length vary: threaded implants require >90 mm of femoral length,[12] press-fit implants require >50 mm,[42] and preloaded compression implants require >45 mm.[43] Residual tibial length ≤50 mm may not provide adequate implant surface area available for osseointegration, but this remains a topic of debate. Although a few case series have explored the use of BAL in individuals with transhumeral amputations,[40] consensus on specific length requirements for the humerus remains lacking. Availability of other press-fit implants to accommodate different residual lengths, diameters, and anatomical variations varies across the world. Further anatomical relative contraindications include a history of wound healing complications, contractures, or limited range of motion of the contralateral joints and insufficient contralateral limb function to undergo rehabilitation. Furthermore, an Oxford Scale (Medical Research Council Manual Muscle Testing scale) score of less than 4 in the muscle groups around the adjacent joint and any comorbidity in the contralateral extremity that precludes effective rehabilitation also constitute contraindications.[14,25,26] Previously resolved skin-contact issues related to using a socket prosthesis would not specifically be the cause for exclusion.[14,25,26]

5. Physiological Considerations

5.1. Screening

The successful anchorage of a BAL necessitates a robust local hematopoietic system at the site of endosteal injury resulting from the implantation.[44] A healthy bone bed is essential to initiate the osteoclastogenesis–angiogenesis coupling of de novo bone formation at the bone–implant interface.[45,46] To evaluate physiological factors for the perioperative management of patients, it is mandatory to conduct a thorough medical history, physical examination, and laboratory evaluation. The evaluation should be completed in an elective clinic visit before the date of surgery.

5.1.1. Laboratory Tests. This routine evaluation should include a comprehensive metabolic panel (which includes sodium, blood urea nitrogen [BUN], and creatinine), C-reactive protein, erythrocyte sedimentation rate, coagulation profile (PTT/INR), complete blood count with differential, albumin/prealbumin, vitamin D, calcium, thyroid-stimulating hormone (TSH), and hemoglobin A1C (HbA1c).[47] In addition, smoking patients should have 2 negative nicotine/cotinine tests 6–8 weeks apart and be nicotine-free for 6 months preoperatively. Additional tests will need to be performed at the time of surgery to confirm abstinence.[48] Optimizing metabolic bone healing potential involves closely monitoring specific laboratory values. Any abnormalities in these values could impede implant survival, increase the risk of complications, and negatively affect the osseointegration of BAL.

5.1.2. Patient Demographics, Medical History, and Screening Tools. Age requirements for BAL candidates vary depending on the implant type. For the threaded implants, candidates must be

between 22 and 65 years, while for press-fit and preloaded compression implants, the age range is generally 18 to 65 with the only absolute press-fit criteria being skeletal maturity. Although there are instances of patients older than 70 years undergoing BAL surgery, there is insufficient research to conduct a subgroup analysis for this age group. The average age reported in current literature is approximately 46.06 ± 2.76 years. Height, weight, and body mass index (BMI) are basic metrics that help assess the patient's suitability for surgery and prosthetics selection. It is important to calculate and use amputation-adjusted BMI for amputees, which accounts for the missing limb.[49] Candidates for press-fit and preloaded compression implants should have a BMI between 18.5 and 40 kg/m^2 and weigh no more than 111 kg (245 lbs) without the prosthesis.[43] While there is no stated BMI or weight range for press-fit implants, weight limits are typically due to the associated connector that will be used with weight limits varying by manufacturer. For threaded implants, candidates should weigh less than 100 kg (220 lbs). A full medical history is important to determine any comorbidities that might pose an additional risk. Patients should be objectively assessed for potential drug or alcohol abuse. Screening test examples include a score less than 6 on the Drug Abuse Screening Test,[50] indicating no substance use, and less than 6 on the Michigan Alcoholism Screening Test,[51] indicating no alcoholism, to be considered suitable candidates for bone-anchored limb surgery.

5.1.3. Physical Examination. Patients with medical comorbidities (especially elderly patients) undergoing BAL surgery require thorough, timely, and team-based preoperative assessment to ensure adequate cardiopulmonary function to withstand anesthesia and blood loss. A routine preoperative physical examination is essential, and patients with comorbidities should be evaluated by medical specialists or an anesthesiologist. Consultation with a vascular surgeon is recommended for patients with significant previous vascular trauma to assure adequate blood flow for successful healing. Significant peripheral vascular disease has traditionally been considered a contraindication for BAL but may not be absolute.

5.2. Eligibility

Ideal candidates are individuals aged 18 years and older with a BMI between 18.5 and 40 kg/m^2, well-controlled diabetes (HbA1c < 7), and generally good health with stable comorbidities if present. Active acute or chronic infections are considered contraindications for BAL. In addition, a history of local infection of the residual limb or previous osteomyelitis (excluding cases distal to amputation) may significantly increase the risk of infection. Patients with poorly controlled diabetes mellitus, those with immunosuppression, or those taking long-term medications affecting bone metabolism are at increased risk of adverse events. Coagulopathy, neuromuscular, cardiopulmonary, and autoimmune diseases should be thoroughly evaluated to ensure patient safety. Other physiological exclusions include severe metabolic disorders that may impair bone formation, epilepsy or other conditions that increase the risk of falls and subsequent fractures, allergic reactions to implant materials, and a history of corticosteroid use within 3 months before surgery and ongoing immunomodulatory therapy and recent irradiation or chemotherapy.

Furthermore, candidates must be devoid of significant bone or vascular diseases and exhibit good overall health. Severe peripheral vascular disease (PVD) is considered a contraindication for BAL because of compromised blood flow and physical deconditioning, which can impede healing, increase infection risk, and affect implant survival.[14,17,20,22,26,28,30,31,33,36,37,52] However, a case series by Al-Muderis[29] demonstrated that PVD might not be an absolute contraindication, with some patients showing marked improvement after transtibial BAL surgery. This suggests that the benefits of increased mobility may outweigh the risks of potential infection, warranting further investigation.[29] Patients with uncontrolled diabetes are generally deemed to be relatively contraindicated for BAL. However, a small case series documented favorable outcomes in diabetic patients with osseointegrated BAL implants, suggesting potential benefits of BAL in this group.[53] Tumors, while not a contraindication, might warrant additional discussion as the future need for radiation or chemotherapy might compromise the bone and the implant.[54] These patients may be considered for BAL despite the anticipated higher risk of perioperative complications because of the improved functional outcomes and quality of life. Still, there is insufficient current evidence to warrant the inclusion of patients with radiation therapy, severe PVD, uncontrolled diabetes, or diabetes-related amputations in the eligibility criteria for BAL.

6. Psychological Considerations

6.1. Screening

The high prevalence of psychiatric disorders among amputees, ranging from 32% to 84%,[55,56] emphasizes the importance of psychological screening before BAL. Moreover, approximately 25% of middle-aged and older prosthesis users exhibit cognitive impairments, which have been linked to diminished physical function.[57] Given this, cognitive screening is crucial for these populations to assess functional ability and rehabilitation outcomes.[58–60] Anxiety, depression, lack of self-efficacy or resilience, and certain personality traits can negatively affect postoperative pain and function.[57,61–63] Cognitive impairment is prevalent among amputees[64] and is significantly linked to functional mobility, as measured by the Montreal Cognitive Assessment (MoCA).[64] The MoCA[65] is a valuable tool to assess global cognitive function, with a score of 26 or higher indicating normal cognitive function.[66] Objective assessment of cognitive ability is recommended to assure ability to comply with the complex postoperative instruction requirements for BAL surgery and rehabilitation. Patients with psychiatric disorders should be assessed by psychiatric evaluation. The Hamilton Rating Scale for Depression,[67] widely regarded as the gold standard for assessing depression severity and treatment response, or other such evaluations should be considered to evaluate patients before BAL surgery.[68,69]

6.2. Eligibility

Hence, all BAL candidates should undergo a brief screening by a licensed clinical social worker or qualified clinician covering key cognitive domains, including attention, memory, executive functions, and language. In addition to cognitive screening, the treating physician must evaluate candidates to ensure understanding of the risks and commitment to postoperative care and rehabilitation protocols. Psychological contraindications to BAL surgery include significant cognitive impairment (MoCA $<$ 26),[14,26,37] psychological instability,[22] disabling psychiatric disorder,[20,25,38,39] unrealistic expectations, or any condition

compromising safety. Psychiatric consultation may be necessary to determine whether these risks can be mitigated, allowing for surgery to proceed, or whether alternative strategies should be pursued to improve the patient's quality of life. Further research is needed to determine more comprehensive psychological screening tools for BAL candidates and monitor psychological changes after BAL surgery.

7. Lifestyle Considerations and Optimization

7.1. Screening

A thorough evaluation of the patient's lifestyle is essential for maximizing recovery after BAL surgery. Comprehending the profession, individual preferences, and hobbies of the patient can offer a significant understanding of their physical needs and the possible impact on their day-to-day activities. For instance, people who work jobs that need them to perform manual labor or stand and/or sit for extended periods may have more tailored rehabilitation protocols. Similarly, patients who engage in physically demanding sports or other activities might need customized counseling to consider their postoperative restrictions, particularly if they have been able to pursue these activities using a socket-based terminal device. Assessing the patient's living situation and social support networks is also essential. To guarantee compliance with treatment guidelines, which include getting to and from appointments, it is imperative to evaluate the degree of social and physical support that a spouse, partner, or other caregiver can provide at home. BAL surgery candidates must be ready to implement major lifestyle adjustments to enhance their recovery, rehabilitation, and overall surgical success.

7.2. Optimization for Eligibility

7.2.1. Pre-rehabilitation. Pre-rehabilitation is an essential preparatory phase aimed at optimizing the candidate's muscular strength and flexibility, allowing for improved postoperative recovery. This individualized phase should be conducted under the supervision of an experienced physical therapist or physical medicine and rehabilitation physician who will perform a comprehensive preoperative assessment before the surgery.[20,25,70] "Prehabilitation" targets specific areas including core and pelvic floor stability, mobility, joints' range of motion, and strengthening relevant muscle groups. In cases where regular in-person sessions are not feasible, a home exercise program with telehealth monitoring by a physical therapist should be considered. Prehabilitation is discussed in more detail in another article in this Supplement (Melton et al).

7.2.2. Peer Group Support. Structured discussions and peer visits play an integral role in preparing BAL candidates by ensuring that they fully understand the limitations and practical uses of BAL. Arranging peer counseling and support tailored to candidates' demographics provides a trusted resource to address concerns, set realistic expectations, and guide them through the BAL journey. These programs are discussed in more detail in another article in this Supplement (Stanley et al).

7.2.3. Home Safety and Adjustment. To guarantee a safe recovery, candidates should also prepare their home. To reduce the risk of falls, this may entail moving a bed to the first floor, removing tripping hazards, or installing safety features such as handrails. Living in a home with stairs, for example, can have an impact on rehabilitation techniques and may necessitate early intervention to guarantee a seamless postoperative transition. A smooth recovery depends on having secure housing and access to in-home help when needed. For rehabilitation sessions and follow-up visits, reliable transportation arrangements must also be made.

7.2.4. Postoperative Care Providers. Another essential component of preoperative care is pain control. Candidates should create a pain management strategy, in consultation with a specialist, to effectively manage pain following surgery. Another crucial aspect is collaborating with a certified prosthetist, with experience in BAL, who can assist with postoperative care. Before proceeding with surgery, it is essential to ensure that the existing prosthetic components with appropriate characteristics such as microprocessor or hydraulic knees under warranty are functioning properly as they may need to be replaced. The candidates should also be paired with a physiatrist, a physical therapist, and possibly a primary care physician who can help oversee their postoperative care and rehabilitation.

7.2.5. Clinical Clearance and Optimization. Before surgery, candidates should consider any modifiable risk factors associated with anatomical, physiological, or psychological criteria to ensure the best possible recovery. This includes avoiding nicotine and excessive alcohol consumption for at least 6 months, controlling weight, maintaining proper nutrition, and achieving glycemic control. Overall, candidates should prioritize their health by avoiding risky habits and following medical recommendations to ensure optimal outcomes during the recovery process.

8. Considerations for Candidates With Bilateral Limb Loss

Other nuances to consider involve the management of individuals with bilateral limb loss. The aforementioned considerations outlined for unilateral BAL candidates generally extend to bilateral cases, but there are key differences in the timing of surgical interventions and rehabilitation. For bilateral patients with differing amputation levels (ie, transfemoral and transtibial), staged treatment in which 1 limb is fitted with BAL components and rehabilitated (typically transfemoral side first) before surgical intervention is performed on the other side may allow greater ability to control postoperative rehabilitation strategies. This approach allows the patient to adapt to the prosthesis on 1 side, facilitating the transition to bilateral use. In cases where simultaneous bilateral BAL surgery is desired, it is important to carefully determine the patient's initial standing height. This height is often set lower than the patient's standing height before amputation to ensure stability and balance in the initial stages of rehabilitation. Gradual elevation increases are then made over time as the patient becomes accustomed. This step-by-step approach is essential to preventing falls, reducing strain on the musculoskeletal system, and promoting safe and effective rehabilitation (Fig. 4).

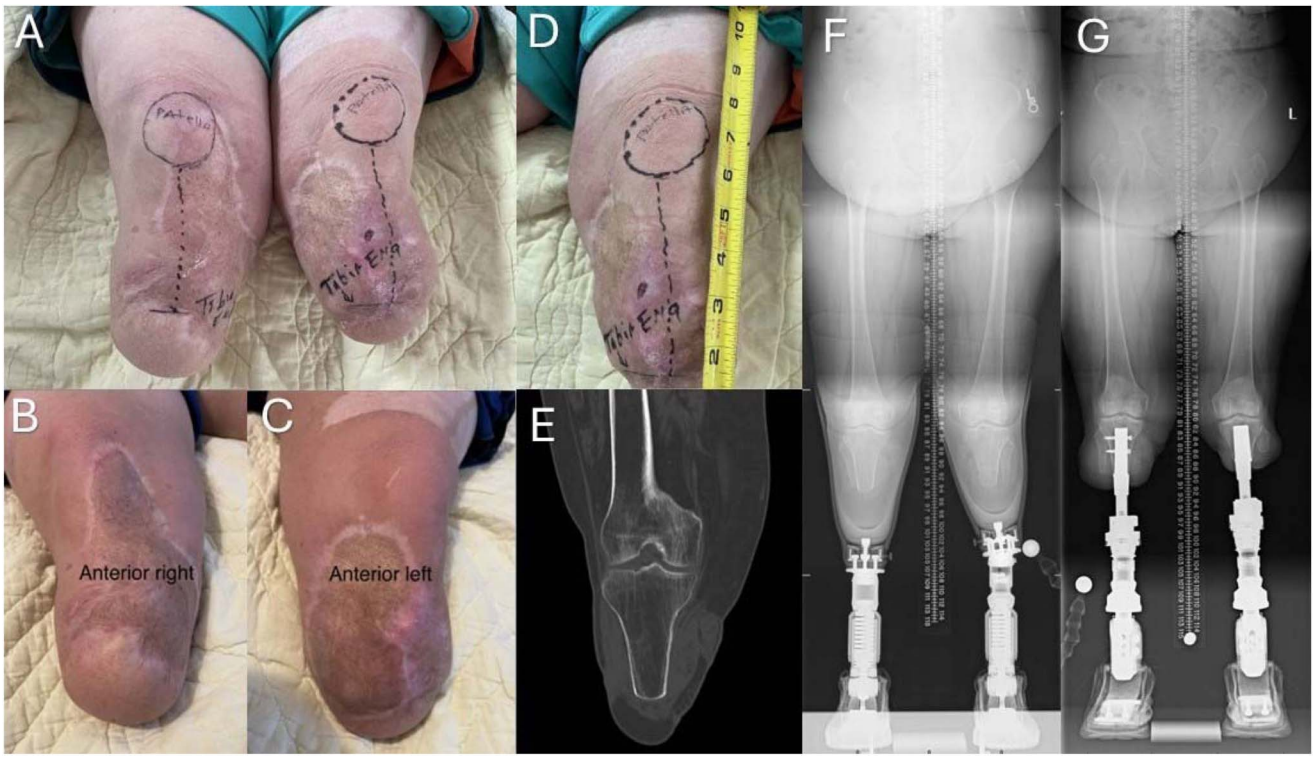

Figure 4. (A–D) Routine physical examination of patients with bilateral transtibial amputation with complex soft-tissue envelope. (E) Coronal view of a CT scan showing the right transtibial residual limb intramedullary canal architecture. (F) Radiographs (standing hip-to-ankle X-ray with prosthesis) of patients with bilateral transtibial amputation using socket prostheses. (G) Radiographs (standing hip-to-ankle X-ray with BAL prosthesis) showing the bilateral press-fit osseointegrated BAL implants in the residual tibia attached to a prosthetic leg. Note balanced knee centers and equal leg lengths.

9. Interdisciplinary Team Assessment

The interdisciplinary team, which may include an orthopaedic surgeon, physiatrist, plastic surgeon, physical therapists, prosthetists, nurses, clinical social worker, physician assistants, athletic trainers, care coordinators, and researchers, is an integral part in the preoperative screening of BAL candidates. Each clinician brings their expertise to ensure a comprehensive screening of the patient's physical and biopsychosocial readiness for surgery.

10. Summary

Bone-anchored limb implantation is becoming a more accepted rehabilitation option for individuals with limb loss. To ensure that a patient is a suitable candidate and will benefit from the procedure, clinicians must consider a range of factors, including anatomical, physiological, psychological, and lifestyle factors. An interdisciplinary team should evaluate each candidate individually to balance the risks and benefits, optimizing the patient for both surgical and rehabilitation outcomes. As research advances and clinical experience grows, eligibility criteria may be expanded to include currently contraindicated conditions. While further research is necessary to refine preoperative optimization protocols, our proposed screening and patient selection workflow may help standardize the process, improve patient safety, and optimize outcomes and recovery.

Appendix 1. Contributors

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