# A Focus on Surgical Optimization: Perioperative Strategies for ACL Reconstruction in Patients with Poor Bone Health

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**Abstract:**

Introduction

Anterior cruciate ligament (ACL) reconstruction is one of the most prevalent orthopedic procedures, with increasing rates among adults over 50 due to growing awareness of the benefits of physical activity and weight-bearing exercise for longevity. Historically, this age group was managed nonoperatively due to concerns about slower recovery and comorbidities. However, modern surgical techniques and rehabilitative protocols have expanded the candidate pool. A major operative consideration in older patients is low bone mineral density (BMD)**,** which affects approximately 30–50% of women and 15–30% of men over 50. Osteopenia and osteoporosis reduce bone mass and alter trabecular architecture, directly impairing tunnel integrity, screw purchase, and graft-to-bone healing—leading to higher risks of fixation failure, delayed union, and revision surgery. Despite these risks, limited guidelines exist for optimizing ACL reconstruction in patients with compromised bone quality. This work proposes a comprehensive, evidence-informed perioperative framework that includes preoperative assessment, intraoperative modifications, and postoperative strategies tailored to patients with low BMD.

Methods

We conducted a focused literature review and integrated clinical experience to develop management protocol for ACL reconstruction to identify key domains of perioperative care in low BMD patients undergoing ACL reconstruction. These included: (1) preoperative bone health screening and optimization; (2) intraoperative graft and fixation modification strategies; and (3) postoperative rehabilitation protocols tailored to bone quality. Special emphasis was placed on pharmacologic support, screw sizing, biologic augmentation, and rehabilitation phasing.

Results

Preoperative: Dual-energy X-ray absorptiometry (DEXA) is recommended in patients >50 years, especially with low BMI, history of corticosteroid use, or prior fragility fractures. Deficiencies in vitamin D and calcium are common and should be corrected (Vitamin D ≥800 IU/day, Calcium 1000–1200 mg/day). Pharmacologic support includes teriparatide or romosozumab, which enhances osteoblast activity and trabecular connectivity. Bisphosphonates, while useful long-term, may delay graft incorporation if used immediately prior to surgery. Prehabilitation, smoking cessation, diabetes control, and multidisciplinary coordination (e.g., endocrinology, physical therapy) support graft integration.

Intraoperative: Bone–patellar tendon–bone (BPTB) autografts are preferred for improved bone-to-bone healing. The probe technique is employed to assess medial, lateral, and inferior tibial tunnel wall integrity to determine optimal interference screw size (Very strong bone: probe cannot indent walls → screw = tunnel diameter; Strong bone: probe indents 1–2 walls → screw = +1 mm; Weak bone: probe indents all walls → screw = +2 mm). Screw length should be ~5 mm shorter than tunnel depth. Metal screws are favored for superior fixation. Posterior wall blowout during femoral tunnel creation must be avoided; if it occurs, suspensory fixation is used. PRP, collagen scaffolds, or cement augmentation may be used to promote healing.

Postoperative: Weight-bearing is initially restricted in severely osteoporotic patients to reduce micromotion at the graft-tunnel interface. Vitamin D/calcium supplementation continues. Teriparatide is maintained post-op in high-risk patients for enhanced osseous integration. Rehabilitation is phased:

- Phase I (0–2 wks): pain and edema control, quadriceps activation
- Phase II (2–6 wks): gentle ROM, closed-chain movement
- Phase III (>6 wks): progressive strengthening; impact activities delayed ≥3–4 month

Radiographs and/or CT imaging monitor tunnel expansion or fixation failure. Assistive devices or gait trainers may be necessary to prevent early overload. Graft incorporation is slower; timelines should be extended accordingly.

Discussion

Low BMD complicates all stages of ACL reconstruction. Optimal outcomes require early identification of bone quality risk factors and implementation of targeted interventions. Pharmacologic therapies such as teriparatide and romosozumab, combined with calcium and vitamin D, improve the biologic environment for fixation. Intraoperative decisions such as graft type, screw size, and use of biologics must be individualized. The probe technique is a novel, cost-effective method for screw selection in weak bone. Postoperatively, conservative loading and extended rehabilitation reduce the risk of tunnel widening, fixation loosening, or hardware failure. Importantly, the risk of revision is higher in this group, and revision surgery requires appropriate spacing (≥4 months post bone grafting) and repeat bone density evaluation. Longitudinal data support this phased approach to maximize fixation strength and functional outcomes.

Significance

As the population ages and remains active, ACL reconstruction in patients with low bone density will become increasingly common. Traditional protocols may not account for the unique risks in this demographic. This comprehensive strategy provides clinicians with a structured framework for pre-, intra-, and postoperative decision-making. By tailoring care to bone health status, we can reduce failure rates, improve graft longevity, and enhance patient function. Future prospective studies should validate the probe technique and pharmacologic protocols across larger cohorts.