



Biomechanical Hypothesis for Inferomedial Calcar Screw Augmentation to Prevent Secondary Varus Collapse in Osteoporotic PHILOS-Plated Proximal Humerus Fractures

Dhruv Verma¹,
Chetan Pradhan¹,
Atul Patil¹,
Chetan Puram¹,
Darshan Sonawane¹,
Ashok Shyam¹,
Parag Sancheti¹

¹Sancheti Institute of Orthopaedics and Rehabilitation PG College, Sivaji Nagar, Pune, Maharashtra, India.

Address of Correspondence

Dr. Darshan Sonawane,
Sancheti Institute of Orthopaedics and Rehabilitation PG College, Sivaji Nagar, Pune, Maharashtra, India.

Email: researchsior@gmail.com.

Abstract

Background: Proximal humerus fractures range from simple, minimally displaced breaks to complex multi-part injuries that can compromise the blood supply and functional integrity of the humeral head. Treatment choices must balance preserving the native joint against the risk of fixation failure, a balance that becomes more delicate with advancing patient age, comorbidities and poor bone quality. Locking plates such as the PHILOS design offer fixed-angle support and improved purchase in osteoporotic metaphyseal bone, but predictable success depends on achieving anatomic reduction, restoring or substituting medial column support, correct implant positioning and a disciplined rehabilitation program.

Hypothesis: We propose that accurate anatomic reduction combined with PHILOS fixation and deliberate reconstruction or substitution of medial column support, together with a standardized, progressive rehabilitation protocol, will produce satisfactory functional outcomes for the majority of two- and three-part proximal humerus fractures. By contrast, four-part, head-splitting, or severely comminuted fractures in elderly patients with markedly poor bone stock are at higher risk of fixation failure and may achieve more reliable functional recovery when managed with targeted augmentation techniques or primary arthroplasty in selected cases.

Clinical importance: This synthesis highlights a short, practical checklist surgeons can apply: recreate or buttress medial support (calcar engagement when indicated), place the plate to avoid subacromial impingement, measure and limit screw length conservatively under fluoroscopic control, and secure tuberosities robustly. Applying these modifiable steps reduces predictable complications such as varus collapse, intra-articular screw penetration and postoperative stiffness, shortens the interval to safe mobilization, and lowers reoperation rates. Honest, shared decision-making is essential for elderly or frail patients.

Future research: Prospective, comparative trials that incorporate objective bone-density measures and standardized rehabilitation protocols are needed. Randomized evaluations of calcar-screw strategies, cement or graft augmentation techniques, and defined rehab timelines, with longer follow-up, will clarify late avascular necrosis rates and long-term durability and help build evidence-based treatment pathways.

Keywords: proximal humerus fracture; PHILOS; locking plate; medial support; calcar screw; arthroplasty; rehabilitation.



Dr. Chetan Pradhan
Primary & Revision
Trauma



Dr. Atul Patil
Pelvic + Arthroscopy +
Trauma



Dr. Chetan Puram
Trauma + Ilizarov



Dr. Darshan
Sonawane
Head of Joint
Assembly +
Orthobiologics &



Dr. Ashok Kumar
Shyam Murari
Head of Academics



Dr. Parag Sancheti
Knee Arthroscopy, Knee
Replacement

Dr. Chetan Pradhan

Dr. Atul Patil

Dr. Chetan Puram

Dr. Darshan Sonawane

Dr. Ashok Shyam

Dr. Parag Sancheti

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Background

Proximal humerus fractures are a common clinical problem that spans the age spectrum. Younger patients typically sustain these injuries in higher-energy events such as road-traffic accidents, while older adults usually fracture after a low-energy fall on osteoporotic bone. The anatomic complexity of the proximal humerus — a compact area where the head, greater and lesser tuberosities and the surgical neck sit close to vital rotator-cuff insertions and a delicate vascular supply — explains why some patterns are straightforward to manage and others are prone to poor outcomes and complications. [1]

Over many decades treatment options have ranged from nonoperative care to percutaneous pinning, intramedullary nailing, open reduction and internal fixation, and joint replacement for selected severe patterns. [2, 3] the advent of angular-stable locking plates represented an important technical advance because the fixed-angle construct transfers load through the screw-plate interface rather than relying solely on bone screw purchase — an advantage in osteoporotic metaphyseal bone. [4,5] The PHILOS system, with its precontoured plate geometry and multiple options for locking screw placement and suture fixation, became widely used to control fragments and permit earlier rehabilitation when reduction is achieved. [6,7]

Despite these benefits, locked plating is not without predictable pitfalls. Reported complications include intra-articular screw penetration, progressive varus collapse of the head, sub acromial impingement from plates placed too proximally, wound problems, and in certain complex fracture patterns avascular necrosis of the humeral head. [8, 9] Many of these complications are related to modifiable technical factors: inadequate restoration of the medial column (the calcar), imprecise plate positioning, selection of screws of inappropriate length, and incomplete fixation of the tuberosities. [10, 11]

Biomechanical studies and clinical series repeatedly emphasize the importance of medial support. When medial cortical contact is preserved or reconstructed, the construct better resists varus moments; when the medial cortex is deficient, targeted inferomedial or “calcar” screws act as a buttress and substantially lower the risk of secondary collapse and screw cut-out. [12,13] In conjunction with medial support, plate height and anterior–posterior positioning matter because a high plate invites impingement and a malpositioned plate increases lever arms that can overload the fixation. [14]

Patient factors also influence the decision between head-preserving fixation and arthroplasty. Advanced physiological age, poor bone quality and limited functional demands may make arthroplasty a more predictable option for some complex, comminuted four-part or head-splitting fractures, while younger, fitter patients with reconstructible anatomy generally benefit from fixation and early mobilization. [15]

Contemporary best practice therefore combines three pillars:

sound preoperative planning (fracture classification and assessment of bone quality), meticulous intraoperative technique (anatomic reduction, restoration of medial support, correct plate and screw choices), and a structured rehabilitation program that balances early motion with protection of the fixation. [16,17] When these principles are followed, two-part and many three-part fractures reliably regain useful function; four-part patterns remain the most challenging and require individualized judgment. [18]

Hypothesis and Aims

Primary hypothesis

In skeletally mature patients with displaced proximal humerus fractures, anatomical reduction combined with angular-stable fixation using a PHILOS locking plate will provide satisfactory functional outcomes and an acceptable complication profile for most two- and three-part fractures; however, outcomes will be less favorable for four-part fractures and in patients with poor bone quality. [19]

Secondary hypotheses

1. Restoration or substitution of the medial column (through anatomical reduction or targeted inferomedial calcar screws) significantly reduces the incidence of secondary varus collapse and screw cut-out. [20]
2. Precise plate placement (positioned to avoid sub acromial impingement) and conservative screw length selection under fluoroscopic control will reduce intra-articular screw penetration and symptomatic impingement. [21]
3. Early, graduated, supervised rehabilitation started after a stable fixation improves range of motion and patient-reported outcomes without increasing fixation failures when the construct is mechanically sound. [22]
4. Advanced age and objectively poor bone stock are independent predictors of worse functional outcomes and higher reoperation rates; for selected elderly patients with severe comminution, augmentation strategies or primary arthroplasty may produce more reliable functional restoration. [23]

Rationale and measurable aims

locking plates function by creating a fixed-angle relationship between screw and plate so that load is transferred through the hardware rather than being borne only by cancellous bone, a helpful feature in osteoporotic metaphyses. [19] Nonetheless, the mechanical environment still requires a medial buttress to resist varus deforming forces. Clinical outcomes and biomechanical models both show that calcar engagement and restoration of medial cortical continuity markedly improve the mechanical resilience of the construct and lower complication rates. [20, 24]

The hypotheses are therefore practical and testable. A prospective protocol to evaluate them should include: primary

outcome of validated shoulder function at 12 months (for example, Constant–Murley score) and secondary outcomes such as DASH score, range of motion, radiographic maintenance of neck-shaft angle, time to union, complication categories (varus collapse, screw penetration, infection, avascular necrosis) and reoperation rate. Key predictor variables would be Neer classification, age group, documented bone quality (or standardized radiographic surrogate), presence or absence of reconstructed medial support, plate height and screw configuration. Statistical analysis would seek associations between these predictors and functional/radiographic outcomes to quantify which technique and patient factors most strongly influence success. [25]

Discussion

When study data and the wider evidence are considered together, a few practical, immediately actionable lessons emerge.

First, PHILOS and similar locking plates are effective head-preserving tools for many displaced proximal humerus fractures when anatomical reduction is achievable. Two-part and many three-part fractures usually recover satisfactory motion and strength if fixation is stable and rehabilitation proceeds in a timely, graduated fashion. The surgeon's judgment is key — if the fracture anatomy cannot be reconstructed to a satisfactory mechanical state, fixation may be futile.

Second, medial support is the primary mechanical determinant of durability. Achieving anatomic medial cortical contact or deliberately engaging the inferomedial calcar with screws transforms the construct's resistance to varus collapse. Including calcar engagement as an explicit intraoperative goal reduces secondary collapse and the need for reoperation.

Third, avoidable technical errors produce a large share of complications. Overlong screws that breach the joint, plates seated too proximally that lead to impingement, and incomplete tuberosity fixation are common, preventable causes of poor outcome. Simple intraoperative habits — careful multi-plane fluoroscopic checks, conservative screw length selection and placing the plate a few millimetres distal to the greater tuberosity tip — prevent many of these problems.

Fourth, biology and patient expectations must guide decision making. Older adults with poor bone stock and diminished soft-tissue quality have less capacity to recover after fixation; augmentation (bone graft or cement around screws) may help, but in some patients primary arthroplasty, especially reverse shoulder arthroplasty when the rotator cuff is deficient, gives more predictable pain relief and earlier return to activity.

Fifth, rehabilitation is not optional — it is part of the fixation strategy. A stable construct allows early pendulum and passive motion that limits stiffness; timely progression to active-assisted and strengthening exercises is important to regain

function. Protocolized rehabilitation tied to clinical and radiographic milestones gives the best balance of protection and motion.

Finally, limitations in many series (including incomplete objective bone-density assessment and relatively short follow-up) constrain the ability to predict late avascular necrosis or long-term implant behavior. Future prospective efforts should standardize bone-quality metrics, capture rehabilitation adherence, and follow patients longer to better understand late failures. Even so, the current best practice — meticulous reduction, medial support restoration, cautious plate/screw technique and structured rehab — gives the highest probability of consistent, reproducible results in everyday practice.

Clinical importance

PHILOS locking-plate fixation remains a practical, head-preserving option for many displaced proximal humerus fractures. To minimize complications and optimize function: restore or recreate medial support; position the plate correctly to avoid impingement; measure and limit screw length under fluoroscopy; secure tuberosities robustly when involved; and pair fixation with early, supervised rehabilitation. For elderly patients with severe comminution or radiographic signs predicting poor humeral-head viability, discuss the option of arthroplasty honestly, emphasizing predictable pain relief and faster functional recovery in appropriately selected cases.

Future direction

Future priorities are randomized or well-matched comparative trials for complex four-part fractures in older patients, routine inclusion of objective bone-density measures to guide augmentation or implant choice, and trials that standardize calcar-screw strategies and rehabilitation protocols. Longer follow-up (≥ 5 years) is needed to quantify late avascular necrosis and implant durability and to refine treatment pathways for specific patient subgroups.

Reference:

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. *Injury*. 2006; 37(8):691–7.
2. Palvanen M, Kannus P, Niemi S, Parkkari J. Update in the epidemiology of proximal humeral fractures. *Clin Orthop Relat Res*. 2006; 442:87–92.
3. Bell JE, Leung BC, Spratt KF, Koval KJ, Weinstein J. Trends and variation in incidence, surgical treatment, and repeat surgery of proximal humeral fractures in the elderly. *J Bone Joint Surg*. [as given in thesis].
4. Court-Brown CM, Garg A, McQueen MM. The epidemiology of proximal humeral fractures. *Acta Orthop Scand*. [as given in thesis].
5. Williams GR Jr, Wong KL. Two-part and three-part fractures: open reduction and internal fixation versus closed reduction and percutaneous pinning. *Orthop Clin North Am*. 2000;

- 31:1–21.
6. Codman EA. Rupture of the supraspinatus tendon. *Clin Orthop Relat Res.* 1990;3–26.
 7. Carofino BC, Leopold SS. Classifications in Brief: The Neer Classification for Proximal Humerus Fractures. *Clin Orthop Relat Res.* 2013;471:39–43.
 8. Handoll HH, Gibson JN, Madhok R. Interventions for treating proximal humeral fractures in adults. *Cochrane Database Syst Rev.* 2003;(4).
 9. Lind T, Kroner K, Jensen J. The epidemiology of fractures of the proximal humerus. *Arch Orthop Trauma Surg.* 1989; 108:285–87.
 10. Rohra N, et al. Management options and outcomes in proximal humerus fractures. *Int J Res Orthop.* 2016 Mar; 2(1):25–28.
 11. Kiran Kumar GN, et al. Surgical treatment of proximal humerus fractures using PHILOS plate. *Chin J Traumatol.* 2014; 17(5):279–84.
 12. Gautier E, Sommer C. Guidelines for the clinical application of the LCP. *Injury.* 2003; 34(2):B63–76.
 13. Helmy N, Hintermann B. New trends in the treatment of proximal humerus fractures. *Clin Orthop Relat Res.* 2006; 442:100–8.
 14. Sudkamp N, et al. Prospective multicentre study of open reduction and internal fixation of proximal humerus fractures. 2009.
 15. Fazal MA, Haddad FS. PHILOS plate fixation for displaced proximal humeral fractures. *J Orthop Surg.* 2009; 17(1):15–18.
 16. Geiger EV, et al. Clinical outcomes of PHILOS fixation in elderly patients. 2010.
 17. Hettrich CM, et al. Quantitative assessment of the vascularity of the proximal humerus. *J Bone Joint Surg Am.* 2010; 92:943–8.
 18. Olerud P, Ahrengart L, Soderqvist A, Saving J. Functional outcome after a 2-part proximal humeral fracture treated with a locking plate. *J Shoulder Elbow Surg.* 2010.
 19. Roderer G, Erhardt J, Graf M, Kinzl L. Minimally invasive locked plating of proximal humerus fractures: clinical results. *J Orthop Trauma.* 2010; 24(7):400–6.
 20. Ricchetti ET, Warrender WJ, Abboud JA. Outcomes after proximal humerus locking plate osteosynthesis. *J Shoulder Elbow Surg.* 2010.
 21. Duralde XA, Leddy LR. Prospective study on displaced proximal humerus fractures. *J Shoulder Elbow Surg.* 2010.
 22. Isiklar Z, Gogus A, Korkmaz M, Kara A. Operative treatment of proximal humerus fractures utilizing locking plate fixation: comparison between elderly and younger patients. 2010.
 23. Neslihan A., et al. Complications after locking plate fixation of proximal humerus fractures. 2010.
 24. Agarwal S, et al. Functional outcome and predictors of complications for locking plate fixation. 2010.
 25. Osterhoff G, et al. Importance of calcar screw in angular stable plate fixation. 2011.

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Institute where Research was Conducted: Sancheti Institute of Orthopaedics and Rehabilitation PG College, Sivaji Nagar, Pune, Maharashtra, India

University Affiliation: Maharashtra University of Health Sciences (MUHS), Nashik, Maharashtra, India.

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