CQ HAND + UPPER LIMB
SPECIALIST ORTHOPAEDIC SURGEON

EVIDENCE SUMMARY

Proximal Humerus Fracture ORIF (Plate and Nail Fixation)

Overview

- Locking plate fixation of proximal humerus fractures in patients older than 60 years is associated with a 44% complication rate and a 34% failure rate [1].
- ORIF of nonosteoporotic proximal humeral fractures with locking plates leads to favorable functional and radiologic outcomes at a minimum of 10 years of follow-up [2].
- Nail versus plate fixation of three-part proximal humeral fractures yields similar 1-year outcomes, suggesting both techniques are useful for internal fixation [3].
- Percutaneous treatment of selected proximal humeral fractures results in predictable union and good clinical results with a low rate of complications [5].
- Fixation of proximal humeral fractures with locking plates or locking intramedullary nails produces similar clinical and radiologic results [6].
- The locking plate is an excellent device for managing displaced unstable proximal humeral fractures and expands the indications for ORIF in these fractures [7].
- Distal AO/OTA C-type distal humerus fractures in older adults can be treated reliably with good outcomes using ORIF with modern locking plates [10].
- Locking plates are a good treatment alternative for elderly patients with displaced 2-part fractures of the surgical neck of the proximal humerus, offering acceptable complication rates and functional outcomes, provided rigorous attention is paid to avoid screw penetration [11].
- Patients undergoing ORIF for proximal humerus fracture dislocations have reasonable functional outcomes but relatively high avascular necrosis and reoperation rates [14].
- There are no level 1 studies in the English language literature comparing ORIF with hemiarthroplasty for proximal humeral fractures [17].
- Intramedullary fixation represents an alternative treatment option for proximal humeral fractures with specific fixation and biologic advantages, including reported outcomes comparable with other techniques [18].
- Locking plate fixation appears to provide a good option for the majority of patients with unstable proximal humeral fractures, with good functional outcomes [24].

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Anatomy & Pathophysiology

- Reverse total shoulder arthroplasty can reliably improve shoulder function, patient satisfaction, and pain levels after failed open reduction and internal fixation of proximal humerus fractures [8].
- Greater tuberosity healing does not impact reverse shoulder arthroplasty biomechanics during abduction or forward flexion [30].
- Greater tuberosity healing affects reverse shoulder arthroplasty biomechanics during external rotation [30].
- Range of motion and strength thresholds can identify subjects with normal shoulder function in the context of proximal humerus fractures [31].
- With minimal and moderate amounts of glenohumeral abduction, glenohumeral joint forces are significantly displaced superiorly when inferior tuberosity placement occurs during hemiarthroplasty for four-part proximal humeral fractures [32].
- The biomechanical literature regarding proximal humerus fracture implants is diverse and heterogeneous [33].
- Biomechanical results regarding the safe distance between humerus shaft fracture and distal locking screws in antegrade nailing require confirmation with clinical studies [34].
- A minimally invasive approach combined with a novel anatomical locking plate provides a biomechanical basis to guide clinical treatment of scapular body fractures [35].
- Modified minimally invasive reduction osteosynthesis system (MIROS) fixation for Neer 2 and 3-Part proximal humeral fractures provides adequate fracture stability and permits early shoulder motion [36].
- Modified minimally invasive reduction osteosynthesis system (MIROS) fixation for Neer 2 and 3-Part proximal humeral fractures yields satisfactory functional and radiologic outcomes with fewer complications [36].
- Shoulder rotational ability is improved by systematically repairing tuberosities around the implant in complex shoulder fractures treated by reverse shoulder arthroplasty, provided their consolidation is anatomic [39].
- The insertion of the deltoid muscle in a 90° abduction position in the scapula plane is recommended for assessing objective strength using the Constant score [42].
- Dominance of the affected shoulder has no influence on functional and quality of life outcomes compared with the nondominant shoulder and should not be used to make treatment decisions [44].
- Reliable bony union and improved shoulder function can be expected with thoughtful surgical planning, appropriate implant choice, and meticulous surgical technique in the management of clavicle nonunion and malunion [45].
- Robot navigation-assisted intramedullary nail treatment for humeral shaft fractures helps surgeons determine the insertion point and proximal opening direction faster and more easily [46].
- Robot navigation-assisted intramedullary nail treatment for humeral shaft fractures shortens surgical time and reduces bleeding [46].

- Robot navigation-assisted intramedullary nail treatment for humeral shaft fractures avoids more intraoperative fluoroscopy [46].
- Robot navigation-assisted intramedullary nail treatment for humeral shaft fractures enables patients to achieve better shoulder functional outcomes [46].
- There is variability in the glenopolar angle with increased AP rotational offset of the shoulder radiograph, revealing inaccuracies even at institutions with established protocols [47].
- The SB suture anchor construct has superior interface contact immediately after fixation in humeral greater tuberosity fracture compared to the DR construct [48].
- The DR suture anchor construct offers better contact performance at all abduction angles with applied force in humeral greater tuberosity fracture compared to the SB construct [48].
- Varus and antecurvatum proximal humerus deformities as small as 15 degrees are associated with statistically significant alterations in glenohumeral joint mechanics in proximal humeral fracture malunion [49].

Classification

- The HGLS classification is a reliable method of describing fractures of the proximal humerus compared with the Neer and AO systems [79].
- The Neer fracture classification differentiates function in patients treated with locked plating for unstable proximal humeral fractures [82].

Clinical Presentation

- Locking plate fixation of proximal humerus fractures in patients older than 60 years is associated with a 44% complication rate and a 34% failure rate [1].
- Percutaneous treatment of selected proximal humeral fractures results in predictable union and good clinical results with a low rate of complications [5].
- Operative treatment, particularly open reduction and internal fixation, is an independent risk factor for inpatient adverse events and mortality in older-aged patients admitted with an isolated fracture of the proximal humerus [12].
- A majority of patients with proximal humeral fractures undergo non-operative treatment [20].
- Surgical treatment of proximal humerus fractures remains far from straightforward, with unpredictable outcomes where factors associated with poor results include being a woman, four-part fracture dislocation, and absence of metaphyseal head extension [64].

Investigations

- Locking plate fixation of proximal humerus fractures in patients older than 60 years is associated with a 44% complication rate and a 34% failure rate [1].
- ORIF of nonosteoporotic proximal humeral fractures with locking plates leads to favorable functional and radiologic outcomes at a minimum of 10 years of follow-up [2].
- Percutaneous treatment of selected proximal humeral fractures results in predictable union and good clinical results with a low rate of complications [5].
- In young, active patients with delayed presentation of complex proximal humeral fractures, ORIF with osteotomy and bone grafting is recommended to preserve the humeral head despite the risk of avascular necrosis, as conservative management yields poor functional outcomes [9].
- Failure of the calcar screw to purchase both the proximal and distal fragments was associated with a significantly higher rate of failure of fixation in the surgical treatment of proximal humeral fractures using a locking plate [16].
- The inherent nature of medial comminution of proximal humeral fracture may lead to inferior radiographic outcomes [76].
- BMD changes appeared swiftly in the proximal humerus after treatment of displaced 3- or 4-part fractures with ORIF, particularly affecting the proximal diaphysis [91].
- Intraoperative 3D imaging with a 160° orbital rotation yields sufficient image quality, enabling the reliable identification of intra-articular screws during plate osteosynthesis of the proximal humerus [92].

Treatment

OPERATIVE FIXATION: LOCKING PLATES

- Locking plate fixation of proximal humerus fractures in patients older than 60 years is associated with a 44% complication rate and a 34% failure rate [1].
- ORIF of nonosteoporotic proximal humeral fractures with locking plates leads to favorable functional and radiologic outcomes at a minimum of 10 years of follow-up [2].
- Primary ORIF is supported for medically fit patients with severely displaced fractures or fracture-dislocations of the proximal humerus in centers with appropriate expertise [4].
- Percutaneous treatment of selected proximal humeral fractures results in predictable union, good clinical results, and a low rate of complications [5].
- The locking plate is an excellent device for managing displaced unstable proximal humeral fractures and expands the indications for ORIF in these cases [7].
- Locking plates are a good treatment alternative for elderly patients with displaced 2-part fractures of the surgical neck, offering acceptable complication rates and functional outcomes, provided screw penetration is avoided [11].

- Operative treatment, particularly open reduction and internal fixation, is an independent risk factor for inpatient adverse events and mortality in older-aged patients admitted with an isolated proximal humerus fracture [12].
- Failure of the calcar screw to purchase both the proximal and distal fragments is associated with a significantly higher rate of fixation failure when using locking plates [16].
- Using the Locking Proximal Humerus Plate for all types of proximal humeral fractures is a reliable procedure with good results when careful planning and familiarity with the technique are maintained [19].
- Early results with locked plate fixation are encouraging, providing a potentially viable alternative to prosthetic replacement [23].
- The combined application of medial anatomical locking plate fixation and minimally invasive lateral locking plate fixation is effective in maintaining reduction and preventing varus collapse and implant failure in fractures with an unstable medial column [56].
- The Humerus Block technique is a predictable, minimally invasive, percutaneous operative technique for various proximal humeral fractures that results in good pain relief, mobility, and pull force with a low incidence of avascular necrosis [78].
- Long PHILOS plate fixation provides reliable secure fixation for complex humeral fractures, including long segment periarticular fractures, segmental fractures involving the proximal humerus and shaft, periprosthetic fractures around well-fixed humeral resurfacing prostheses, and pathological fractures [71].
- Dual plating is indicated for certain cases, particularly old ununited fractures where intramedullary nailing is difficult, but is contraindicated in severely comminuted fractures requiring extensive dissection [68].

OPERATIVE FIXATION: INTRAMEDULLARY NAILS

- Fixation of proximal humeral fractures with locking plates or locking intramedullary nails produces similar clinical and radiologic results [6].
- The intramedullary nail is superior to the locking plate in reducing total complications, intraoperative blood loss, operative time, postoperative fracture healing time, and postoperative humeral head necrosis rate [13].
- Intramedullary fixation represents an alternative treatment option with specific fixation and biologic advantages and reported outcomes comparable to other techniques [18].
- Modern proximal humeral nail designs and techniques have demonstrated promising outcomes and can provide stable fixation [70].

OPERATIVE FIXATION: OTHER TECHNIQUES

- Double plate fixation combined with autogenous iliac crest bone grafting results in successful salvage of humeral shaft nonunion after prior failed surgical interventions [15].
- An anterior approach for open reduction and internal fixation of humeral midshaft fractures allows supine positioning and yields union and complication rates comparable to a posterior approach [54].
- The use of a modified anterolateral approach and intra-osseous portal is safe and effective for minimally invasive reduction and plating of three-part proximal humeral fractures [53].

OPERATIVE VS. NON-OPERATIVE MANAGEMENT

- Similar 1-year outcomes for nail versus plate fixation of three-part proximal humeral fractures suggest both techniques are useful for internal fixation [3].
- A majority of patients with proximal humerus fractures undergo non-operative treatment [20].
- Nonsurgical management of proximal humerus fractures decreased during the study period analyzed in one cost-minimization analysis [69].
- There is no significant difference in clinical outcomes at 2 years between surgery and non-operative treatment in patients 60 years of age or older with displaced 2-part fractures of the proximal humerus [59].
- Nonsurgical treatment should have a more prominent role in the treatment of proximal humeral fractures, with better midterm outcomes observed compared to surgical treatment in one study [72].
- Treatment for proximal humerus fractures remains controversial, with nonsurgical management demonstrating successful outcomes and union rates greater than 90% [60].
- Most proximal humeral fractures in elderly patients can be treated nonoperatively with good functional outcomes [73].
- Short and long periods of immobilization yield similar results for nonoperatively treated proximal humeral fractures, independent of the fracture pattern [63].

PERIOPERATIVE CONSIDERATIONS AND RISK FACTORS

- The most important risk factors for postoperative opioid dependence following proximal humerus fractures are preoperative dependence and fracture complexity [80].

Complications

- Locking plate fixation of proximal humerus fractures in patients older than 60 years is associated with a 44% complication rate and a 34% failure rate [1].
- ORIF of nonosteoporotic proximal humeral fractures with locking plates leads to favorable functional and radiologic outcomes at a minimum of 10 years of follow-up [2].
- Percutaneous treatment of selected proximal humeral fractures results in a low rate of complications [5].
- Operative treatment, particularly open reduction and internal fixation, is an independent risk factor for inpatient adverse events and mortality in older-aged patients admitted with an isolated fracture of the proximal humerus [12].
- Intramedullary nailing is superior to locking plate fixation in reducing the total complication rate of proximal humerus fractures [13].
- Intramedullary nailing is superior to locking plate fixation in reducing the postoperative humeral head necrosis rate of proximal humerus fractures [13].
- ORIF of proximal humerus fracture dislocations carries a high rate of reoperation [27].

- The incidence of major wound complications after fixation of distal humerus fractures is substantial, with Grade III open fractures and the use of a plate to stabilize the olecranon osteotomy identified as significant risk factors [28].
- Acute deep infection after ORIF of proximal humeral fractures is a devastating complication with high complication rates, poor functional outcomes, and a notably high nonunion rate [93].
- Fixation of proximal humeral fractures in elderly patients using cement-augmented locked plates may result in lesser implant failure and total complication rates compared to using a locked plate alone [96].
- The overall complication rate of locking plate osteosynthesis for proximal humeral fractures has been decreasing considerably within the last years [97].
- In-hospital complications are more likely to occur after reverse shoulder arthroplasty than after locked plating for proximal humeral fractures [98].
- The risk of short-term complications is highest in patients undergoing shoulder arthroplasty for a fracture compared with nonfracture indications [101].
- Mortality at 1 year for fragility proximal humerus fractures is universally high regardless of risk factors [103].
- Complications of shoulder arthrodesis are not uncommon, including nonunion, malunion, fracture, and infection [107].

Recovery

- Locking plate fixation of proximal humerus fractures in patients older than 60 years is associated with a 44% complication rate and a 34% failure rate [1].
- ORIF of nonosteoporotic proximal humeral fractures with locking plates leads to favorable functional and radiologic outcomes at a minimum of 10 years of follow-up [2].
- Percutaneous treatment of selected proximal humeral fractures results in predictable union and good clinical results with a low rate of complications [5].
- Shoulder function, patient satisfaction, and pain levels can be reliably improved after reverse total shoulder arthroplasty for failed open reduction and internal fixation of fractures of the proximal humerus [8].
- In young, active patients with delayed presentation of complex proximal humeral fractures, ORIF with osteotomy and bone grafting is recommended to preserve the humeral head, despite the risk of avascular necrosis, as conservative management yields poor functional outcomes [9].
- The intramedullary nail is superior to locking plate in reducing total complication, intraoperative blood loss, operative time, postoperative fracture healing time, and postoperative humeral head necrosis rate of proximal humerus fractures [13].
- Patients undergoing ORIF for proximal humerus fracture dislocations have reasonable functional outcomes but relatively high avascular necrosis and reoperation rates [14].
- Double plate fixation combined with autogenous iliac crest bone grafting results in successful salvage of humeral shaft nonunion after prior failed surgical interventions [15].

- Elective implant removal in symptomatic patients after internal fixation of proximal humerus fractures improves clinical outcome, with symptomatic patients showing statistically significant improvement of the Constant score after implant removal [21].
- Delays beyond 5 days to surgery do not affect outcome following plate and screw fixation of proximal humerus fractures [22].
- ORIF of proximal humerus fracture dislocations carries a high rate of reoperation [27].
- Early active motion rehabilitation for postoperative treatment after locking plate fixation of proximal humerus fractures was not inferior to a restrictive treatment protocol after a follow-up period of 24 months [38].
- Intramedullary stabilization of proximal humeral fractures with an angular and sliding stable antegrade locking nail allows for immediate postoperative mobilization [50].
- Patients with proximal humeral fractures treated with early range of motion exercises do well, largely returning to baseline functional status by 1 year [51].
- Treatment with continuous passive motion (CPM) increases the range of motion after plate osteosynthesis of proximal humerus fractures in the first 6 weeks after surgery, but this effect is not sustained after 3 and 12 months [52].
- External fixation is a preferred surgical treatment option for paediatric proximal humerus fractures because early mobilization of the affected limb can be realized [62].
- The locked plate may prove useful in earlier pain-free rehabilitation of proximal humeral fractures [66].
- Ten years after locked plating of displaced proximal humeral fractures, patients show good to excellent outcomes in the majority of cases with no relevant decline compared with the shoulder function 1 year after surgery [67].

Key Evidence

- [L4] ORIF of proximal humerus fractures with locking plates in patients aged >60 years resulted in a 44% complication and 34% failure rate. [1] (10.1016/j.jse.2019.11.026)
- [L3] ORIF of nonosteoporotic proximal humeral fractures with locking plates led to favorable functional and radiologic outcomes at a minimum of 10 years of follow-up. [2] (10.1097/corr.0000000000002895)
- [L2] The similar 1-year outcomes for nail versus plate fixation of three-part proximal humeral fractures suggest that both techniques may be useful for internal fixation of these fractures. [3] (10.1007/s11999-011-2056-y)
- [L4] Our results support the use of primary ORIF in medically fit patients with a severely displaced fracture or a fracture-dislocation of the proximal part of the humerus in centers where the expertise to carry out such treatment exists. [4] (10.2106/jbjs.19.00595)
- [L4] Percutaneous treatment of selected proximal humeral fractures results in predictable union and good clinical results with a low rate of complications. [5] (10.1016/j.jse.2006.09.006)

- [L1] Fixation of proximal humeral fractures with locking plates or locking intramedullary nails produces similar clinical and radiologic results. [6] (10.1016/j.jse.2016.02.003)
- [L2] The locking plate is an excellent device in the management of displaced unstable proximal humeral fractures and is expanding the indications for ORIF in these fractures. [7] (10.1016/j.jse.2009.08.008)
- [L4] Shoulder function, patient satisfaction, and pain levels can be reliably improved. [8] (10.1016/j.jse.2016.05.020)
- [L4] In young, active patients with delayed presentation of complex proximal humeral fractures, ORIF with osteotomy and bone grafting is recommended to preserve the humeral head, despite the risk of avascular necrosis, as conservative management yields poor functional outcomes. [9] (10.1016/j.jse.2007.12.012)
- [L3] Distal AO/OTA C-type distal humerus fractures in older adults can be treated reliably and with good outcomes with ORIF using modern locking plates. [10] (10.1186/s12891-022-05431-5)
- [L4] Locking plates appear to be a good treatment alternative in elderly patients with a displaced 2-part fracture of the surgical neck of the proximal humerus with an acceptable complication rate and an acceptable functional outcome; however, rigorous attention has to be paid to avoid screw penetration. [11] (10.1016/j.jse.2009.11.046)
- [L3] Operative treatment, particularly open reduction and internal fixation, is an independent risk factor for inpatient adverse events and mortality in older-aged patients admitted with an isolated fracture of the proximal humerus and should perhaps be offered more judiciously. [12] (10.1016/j.jse.2013.09.006)
- [L1] The intramedullary nail is superior to locking plate in reducing the total complication, intraoperative blood loss, operative time, postoperative fracture healing time and postoperative humeral head necrosis rate of PHF. [13] (10.1186/s13018-019-1345-0)
- [L4] Patients undergoing ORIF for proximal humerus fracture dislocations have reasonable functional outcomes but relatively high avascular necrosis and reoperation rates. [14] (10.1016/j.jse.2022.04.018)
- [L4] Double plate fixation combined with autogenous iliac crest bone grafting results in successful salvage of humeral shaft nonunion after prior failed surgical interventions. [15] (10.1186/s12891-020-03743-y)
- [L3] Failure of the calcar screw to purchase both the proximal and distal fragments was associated with a significantly higher rate of failure of fixation in the surgical treatment of proximal humeral fractures using a locking plate. [16] (10.1302/0301-620x.107b9.bjj-2024-1649.r1)
- [L5] There are no level 1 studies in the English language literature comparing ORIF with hemiarthroplasty for proximal humeral fractures. [17] (10.1016/j.jhsa.2010.07.019)
- [L4] Intramedullary fixation represents an alternative treatment option for proximal humeral fractures with specific fixation and biologic advantages, including reported outcomes comparable with other techniques. [18] (10.5435/jaaos-d-18-00360)
- [L2] Using the Locking Proximal Humerus Plate for treatment of proximal humeral fractures of all types is a reliable procedure, with good results being obtained with careful planning and familiarity with the special features of the operative technique. [19] (10.1097/01.blo.0000137554.91189.a9)
- [L3] A majority of patients with proximal humeral fractures underwent non-operative treatment. [20] (10.1186/s12891-019-2812-9)

- [L4] Symptomatic patients after locked plate osteosynthesis for proximal humerus fractures showed statistically significant improvement of the Constant score after implant removal. [21] (10.1186/s12891-016-0977-z)
- [L3] Timing of surgery did not impact outcomes of patients who underwent ORIF for proximal humerus fractures. [22] (10.1016/j.jse.2025.02.019)
- [L4] Early results with locked plate fixation for the treatment of proximal humerus fractures have been encouraging, providing a potentially viable alternative to prosthetic replacement. [23] (10.5435/00124635-200805000-00008)
- [L4] Locking plate fixation appears to provide a good option for the majority of patients with unstable proximal humeral fractures, with good functional outcomes. [24] (10.1016/j.jse.2006.06.006)
- [L4] ORIF of proximal humerus fracture dislocations carries a high rate of reoperation. [27] (10.1016/j.jse.2021.01.025)
- [L4] The incidence of major wound complications after fixation of distal humerus fractures is substantial, with Grade III open fractures and the use of a plate to stabilize the olecranon osteotomy identified as significant risk factors. [28] (10.1016/j.jse.2013.09.014)
- [L5] Greater tuberosity healing does not seem to impact reverse shoulder arthroplasty biomechanics during abduction or forward flexion; however, it does affect biomechanics during external rotation. [30] (10.1016/j.jse.2019.07.022)
- [L3] Range of motion and strength thresholds can identify subjects with normal shoulder function. [31] (10.1016/j.jse.2010.06.005)
- [L5] With minimal and moderate amounts of glenohumeral abduction, glenohumeral joint forces are significantly displaced superiorly. [32] (10.1016/j.jse.2007.06.017)
- [L4] The biomechanical literature was found to be both diverse and heterogeneous. [33] (10.1186/s12891-015-0627-x)
- [L5] These biomechanical results, although very promising, should be confirmed with clinical studies. [34] (10.1186/s12891-025-08711-y)
- [L5] The study provided a biomechanical basis to guide the clinical treatment of scapular body fractures. [35] (10.1186/s13018-024-04905-7)
- [L3] It is a minimally invasive procedure that provides adequate fracture stability and permits early shoulder motion, with satisfactory functional and radiologic outcomes and fewer complications. [36] (10.1186/s12891-025-08600-4)
- [L2] Early active motion rehabilitation for postoperative treatment after locking plate fixation of proximal humerus fractures was not inferior to a restrictive treatment protocol after a follow-up period of 24 months. [38] (10.1016/j.jse.2025.01.042)
- [L3] Shoulder rotational ability is improved by systematically repairing the tuberosities around the implant, provided their consolidation is anatomic. [39] (10.1016/j.jse.2012.03.011)
- [L3] The authors recommend performing the measurement at the insertion of the deltoid muscle in a 90° abduction position in the scapula plane. [42] (10.1186/s12891-019-2795-6)

- [L3] Dominance of the affected shoulder has no influence and should not be used to make treatment decisions. [44] (10.1016/j.jse.2014.10.006)
- [L5] Reliable bony union and improved shoulder function can be expected with thoughtful surgical planning, appropriate implant choice, and meticulous surgical technique. [45] (10.1016/j.jse.2013.01.022)
- [L3] It can help surgeons determine the insertion point and proximal opening direction faster and more easily, shorten the surgical time, reduce bleeding, avoid more intraoperative fluoroscopy, and enable patients to achieve better shoulder functional outcomes. [46] (10.1186/s12891-024-07848-6)
- [L4] The study demonstrates variability in the glenopolar angle with increased AP rotational offset of the shoulder radiograph, revealing inaccuracies even at an institution with an established protocol. [47] (10.1302/0301-620x.95b8.30631)
- [L5] Findings suggest that despite the SB construct having superior interface contact immediately after fixation, the DR construct offered better contact performance at all abduction angles with applied force. [48] (10.1186/s12891-019-2412-8)
- [L5] Varus and antecurvatum proximal humerus deformities as small as 15 degrees were associated with statistically significant alterations in glenohumeral joint mechanics. [49] (10.5435/jaaos-d-20-00555)
- [L4] Intramedullary stabilization of proximal humeral fractures with an angular and sliding stable antegrade locking nail represents a minimally invasive procedure that provides a high degree of primary stability even in osteoporotic bone and allows for immediate postoperative mobilization. [50] (10.2106/00004623-200300004-00019)
- [L3] Patients with proximal humeral fractures treated with early range of motion exercises do well, largely returning to baseline functional status by 1 year. [51] (10.1016/j.jse.2007.07.016)
- [L1] The treatment with CPM increases the range of motion after plate osteosynthesis of proximal humerus fractures in the first 6 weeks after surgery, but this effect is not sustained after 3 and 12 months. [52] (10.1186/s13018-024-04804-x)
- [L3] The use of the modified anterolateral approach and intra-osseous portal is safe and effective for minimally invasive reduction and plating treatment for three-part proximal humeral fractures. [53] (10.1186/s13018-017-0701-1)
- [L3] An anterior approach allows supine positioning of the patient and yields union and complication rates comparable to those of a posterior approach with plate fixation for the treatment of humeral shaft fractures. [54] (10.1186/s12891-019-2888-2)
- [L4] The combined application of medial anatomical locking plate fixation and minimally invasive lateral locking plate fixation is effective in maintaining operative reduction and preventing varus collapse and implant failure in proximal humerus fractures with an unstable medial column. [56] (10.1186/s13018-020-02094-7)
- [L1] This trial found no significant difference in clinical outcomes at 2 years between surgery and non-operative treatment in patients 60 years of age or older with displaced 2-part fractures of the proximal humerus. [59] (10.1371/journal.pmed.1002855)
- [L5] Treatment for proximal humerus fractures remains controversial, with nonsurgical management demonstrating successful outcomes and union rates greater than 90%. [60] (10.5435/jaaos-d-24-01073)

- [L3] External fixation is a preferred surgical treatment option for paediatric proximal humerus fractures because early mobilization of the affected limb can be realized. [62] (10.1186/s12891-023-07037-x)
- [L2] Short and long periods of immobilization yield similar results for nonoperatively treated proximal humeral fractures, independent of the fracture pattern. [63] (10.2106/jbjs.20.02137)
- [L5] Surgical treatment of proximal humerus fractures remains far from straightforward, with unpredictable outcomes where factors associated with poor results include being a woman, four-part fracture dislocation, and absence of metaphyseal head extension. [64] (10.1097/corr.0000000000002242)
- [L5] The locked plate may prove useful in earlier pain-free rehabilitation of proximal humeral fractures. [66] (10.1016/j.jse.2006.03.013)
- [L4] Ten years after locked plating of displaced proximal humeral fractures, patients show good to excellent outcomes in the majority of cases with no relevant decline compared with the shoulder function 1 year after surgery. [67] (10.1016/j.jse.2013.11.009)
- [L4] Dual plating is still indicated for certain cases, particularly old ununited fractures where intramedullary nailing is difficult, but is contraindicated in severely comminuted fractures requiring extensive dissection. [68] (10.2106/00004623-196345020-00026)
- [L4] Nonsurgical management of proximal humerus fractures decreased during the study period. [69] (10.1016/j.jhsa.2020.03.022)
- [L5] Modern proximal humeral nail designs and techniques have demonstrated promising outcomes and can provide stable fixation. [70] (10.1016/j.jse.2015.11.016)
- [L4] The long PHILOS plate fixation provides reliable secure fixation for the treatment of complex humeral fractures, especially long segment periarticular fractures, segmental fractures involving proximal humerus and shaft, periprosthetic fractures around well-fixed humeral resurfacing prosthesis and pathological fractures. [71] (10.1111/j.1758-5740.2010.00085.x)
- [L3] Nonsurgical treatment should have a more prominent role in the treatment of proximal humeral fractures. [72] (10.1016/j.jse.2011.01.025)
- [L5] Most proximal humeral fractures in elderly patients can be treated nonoperatively with good functional outcomes. [73] (10.2106/jbjs.l.01293)
- [L3] This implies that the inherent nature of medial comminution of proximal humeral fracture may lead to inferior radiographic outcomes. [76] (10.1186/s13018-022-03337-5)
- [L4] The Humerus Block technique is a very good and predictable, minimally invasive, percutaneous operative technique for treatment of various types of proximal humeral fractures that results in very good pain relief, mobility, and pull force in the arm with a low incidence of avascular necrosis. [78] (10.1016/j.jse.2011.07.029)
- [L3] The HGLS classification is a reliable method of describing fractures of the proximal humerus compared with the Neer and AO systems. [79] (10.1016/j.jse.2012.09.018)
- [L3] The most important risk factors for postoperative opioid dependence following proximal humerus fractures are preoperative dependence and fracture complexity. [80] (10.1186/s13018-019-1233-7)

- [L4] With locked plating of unstable proximal humeral fractures, older patients function as well as younger patients; improvement continues until 1 year postoperatively, the Neer fracture classification differentiates function, and polytrauma patients perform worse clinically. [82] (10.1007/s11999-011-1935-6)
- [L1] BMD changes appeared swiftly in the proximal humerus after treatment of displaced 3- or 4-part fractures with ORIF, particularly affecting the proximal diaphysis. [91] (10.1016/j.jse.2022.07.008)
- [L5] Intraoperative 3D imaging with a 160° orbital rotation yields sufficient image quality, enabling the reliable identification of intra-articular screws during plate osteosynthesis of the proximal humerus. [92] (10.1186/s13018-026-06800-9)
- [L4] Acute deep infection after ORIF of proximal humeral fractures is a devastating complication with high complication rates, poor functional outcomes, and a notably high nonunion rate. [93] (10.1016/j.jse.2006.09.021)
- [L1] Fixation of proximal humeral fractures in elderly patients using locked plates with or without cement augmentation has no significant difference in revision rate, but the implant failure and total complication rates may be lesser on using the cement-augmented locked plate for fixation than on using a locked plate alone. [96] (10.1186/s12891-024-07502-1)
- [L4] The overall complication rate of locking plate osteosynthesis for proximal humeral fractures has been decreasing considerably within the last years. [97] (10.1016/j.jse.2016.02.015)
- [L3] The increased in-hospital risk for major adverse events and surgical complications may moderate the enthusiasm associated with RTSA for proximal humeral fractures in patients 65 years and older. [98] (10.1097/corr.0000000000001776)
- [L2] The findings indicate that the risk of short-term complications is highest in patients undergoing surgery for a fracture compared with nonfracture indications. [101] (10.1016/j.jse.2010.11.005)
- [L3] Mortality at 1 year for fragility proximal humerus fractures is universally high regardless of risk factors. [103] (10.1016/j.jse.2022.03.006)
- [L5] Complications are not uncommon, including nonunion, malunion, fracture, and infection. [107] (10.5435/jaaos-d-21-00667)

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