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Comprehensive Study of Surgical management of Proximal Humerus fractures in adults- A REVIEW ARTICLE

Dr.S.S.V.Ramana .A[1], Dr.SankaTulasiram Yashaswi[2]
[1.]Consultant Orthopaedic surgeon and professor of orthopaedic dept. Government general hospital,Guntur
[2.]Consultant Joint replacement surgeon,Yashaswi hospitals, Guntur

The majority of proximal humerus fractures are treated nonoperatively with good functional results. Multiple options exist for treating displaced fractures, without a clear advantage of any one method for a given fracture type. Goals include an adequate reduction and stable fixation to initiate early motion and rehabilitation. Decision-making should be based on patient and injury specifics and surgeon's experience. Various types of fixation, including plates, nails, or percutaneous pins, can maintain sufficient stability to promote shoulder mobility and function. Any of these methods will have few complications when undertaken with appropriate patient selection and careful surgical technique.Locked plating may improve fracture stability in some complex patterns and facilitate early rehabilitation. It is possible that some fractures previously treated with hemiarthroplasty may be managed successfully with locking plates. Prospective study to assess the complications, outcomes, and cost effectiveness of nonoperative management compared to various surgical treatment options is warranted.

Key words: *proximal humerusfracture,humerusnail,lockingplate,shoulder hemiarthroplasty*

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I. Introduction

The goal of treatment for proximal humerus fractures is restoration of a painless shoulder with satisfactory patient functional outcome. Nondisplaced fractures and fractures with minimal displacement and adequate stability are usually successfully treated non-operatively (1,2,3). The main goal in treating displaced fractures or fracture dislocations is to achieve good clinical shoulder function with no pain via restoration of the proximal humeral anatomy—a goal best achieved by open reduction and internal fixation (ORIF) together with the use of locking plates [4-6].A variety of treatment techniques has been proposed including open reduction and internal fixation with proximal humerus plates, hemiarthroplasty as well as percutaneous or minimally invasive techniques such as pinning, screw osteosynthesis, transosseous Suture Fixation and intramedullary nails (7, 8).The aim of this article is to provide an overview over the epidemiology, classification, current treatment options and complications in proximal humerus fractures.

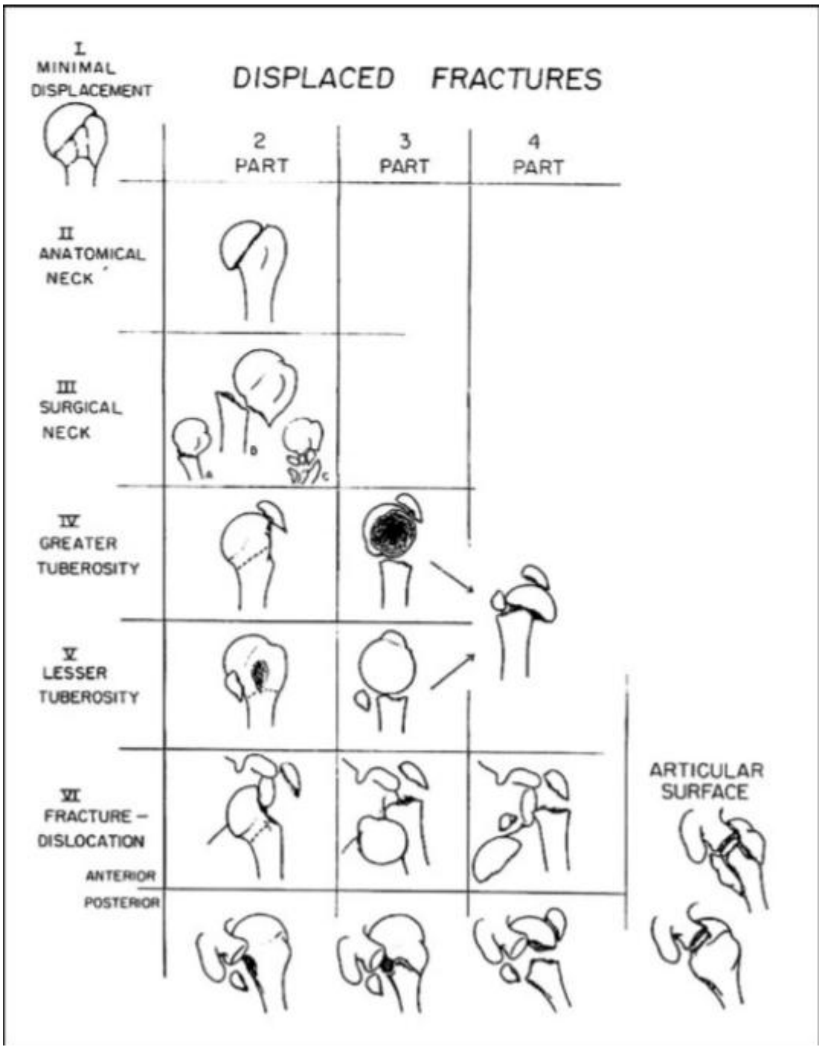
The goals of this article are to enable the reader to: (1) become familiar with the recent literature on the classification of and treatment options for proximal humeral fractures, and (2) better identify fracture characteristics and devise an appropriate treatment plan.

II. Epidemiology:

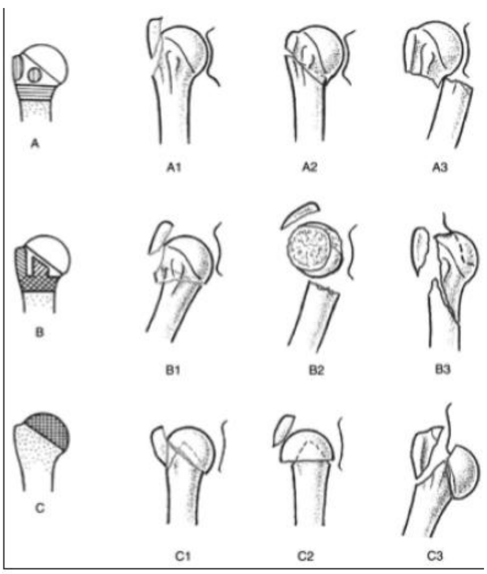
Proximal humerus fractures account for approximately 5% of all fractures and represent the third most frequent fracture in elderly patients (10). More than 70% of patients with these fractures are older than 60 years and 75% are women (12). In the elderly population, most of these fractures are related to osteoporosis (11). According to data in the literature the incidence in the total population is 70/100.000 per annum, but this rises in women over 70 years to 400/100.000 per annum . Risk factors are considered low bone mass, personal history of fractures, low level of physical activity, poor vision, insulin-dependent diabetes and alcohol consumption.

CLASSIFICATION:

1934 Codman described four major fragments in proximal humerus fractures: the head, the lesser tuberosity, the greater tuberosity, and the shaft. A fracture of the proximal humerus can separate one, two, or three of the four major segments from the rest, therefore Codman classified proximal humerus fractures as 2-part, 3-part and 4-part fractures. To assess the vascular status of the humeral head the Hertel radiographic criteria for perfusion of the humeral head are useful (18). In the Hertel criteria, metaphyseal extension of the humeral head of < 8 mm and medialhinge disruption of > 2 mm were determined to be good predictors of ischemia. The combination of metaphyseal extension of the humeral head, medial hinge disruption of > 2 mm, and an anatomic neck fracture pattern had a 97% positive predictive value for humeral head ischemia.



Nowadays commonly used classifications are the Neer classification and the AO/ASIF classification (38). Neer's classification-system is based on Codman's four fragment classification and is divided into 6 groups. All fractures with a displacement <1 cm and an angulation below 45° are classified together in group I. The other groups are determined by the number of fracture fragments, involvement of the articular surface and the direction of dislocation (Fig. 1).



The AO/ASIF classification system for proximal humerus fractures classifies fractures based on the degree of articular involvement and probability of vascular injury according to the general ABCSystem of fracture classification (Fig. 2). Both the Neer and the AO/ASIF classification systems suffer from a poor interobserver reliability and inadequatepredictability of clinical outcome. Furthermore they are not user-friendly for everyday use and often do not correspond to reality at surgery (3). The low reliability of these classifications may cause difficulties in clinical comparative studies. However, training may improve agreement among doctors using the Neer system (6). We still consider Codman's classification to be the most practical since it is not based on the dislocation of the individual fragments, which is sometimes difficult to assess, but focuses on the instability of the affected fragments.Before planning for operative procedure , it is necessary to
determine the vascularity of head, bone quality, choice of implant and method of fixation.

Implants and fixation methods

Minimally invasive techniques
i. Percutaneous Pinning or Screw fixation
ii. Minimally invasive Plating and intramedullary Nailing
iii. External Fixation
Open reduction internal fixation techniques
i. Transosseous suture fixation
ii. Plate - conventional T plate or LCP
iii. Intramedullary Nail - Polarusospolyaxial nail
Replacement Arthroplasty
i. Conventional Arthroplasty
ii. Reverse Shoulder Arthroplasty

III. Operative Treatment

Various methods such as closed reduction and percutaneous pinning(CRPP),tension band wiring,intramedullarynailing, platefixation, Transosseous suture fixation and hemiarthroplasty have demonstrated mixed results.

Fracture pattern ,fracturedisplacement,bonequality,pre-existing rotator cuff disease or arthrosis and patient function are important factors to consider in developing a treatment plan.The primary goal should be a construct sufficiently stable to begin early range of motion of shoulder.(9).

Transosseous Suture Fixation Surgical Technique:

Park et al.2 described different operative approaches for each fracture pattern described by Neer3. For two-partgreater tuberosity fractures, an anterosuperior approach along the Langer lines extending from the lateral aspect of the acromion toward the lateral tip of the coracoid is used. The split occurs in the anterolateral raphe and allows exposure of the displaced greater tuberosity fracture. When a surgical neck fracture exists, Park et al.2 prefer a standard deltopectoral approach. Nonabsorbable suture is used to capture rotator cuff tissue anteriorly, laterally, and posteriorly to the fragment. The displaced humeral head is reduced and fixed to the shaft through drill holes or suture anchors. Three-part fractures involving the greater tuberosity and the surgical neck can be repaired by initially bringing the head to the shaft, followed by reduction and fixation of the greater tuberosity. Flatow et al.4 described an anterosuperior approach and the use of heavy nonabsorbable sutures for greater tuberosity fractures (Fig. 1). Humerus fractures.

IV. Results

Flatow et al.4 reported that all twelve patients who had transosseous suture fixation of an isolated greater tuberosity fracture had good or excellent results with osseous union. Park et al.2, in a review of twenty-eight shoulders with two-part greater tuberosity, two-part surgical neck, and three-part greater tuberosity and surgical neck fractures that were treated with transosseous suture fixation, reported that 78% of the patients had an excellent result according to the criteria of Neer et al.5 and that there was no difference between the results obtained with two-part greater tuberosity fractures and those obtained with two-part surgical neck or three-part fractures. Panagopoulos et al.6 used transosseous suture fixation for four-part valgus-impacted proximal humeral fractures, and the mean Constant-Murley score7 for the operative shoulder was 87 compared with 94 for the contralateral shoulder. Partial osteonecrosis of the humeral head developed in one patient.

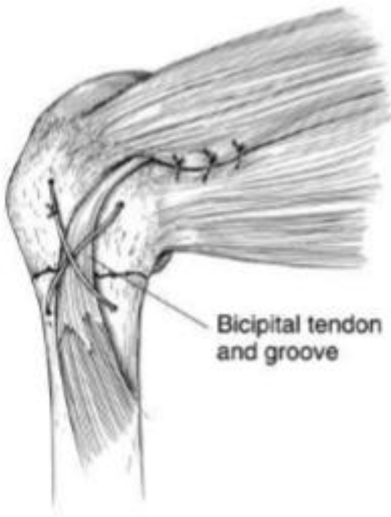


Fig:1- Tension-band construct with transosseous suture fixation can be used for minimally displaced (AO/ASIF type-A) proximal humeral fracture involving the surgical neck, greater tuberosity, or lesser tuberosity.

Closed or mini-open reduction Percutaneous K-wire fixation:

Indications for CRPP include 2-part fractures of the surgical neck, isolated greater tuberosity fractures, 3-part fractures of the surgical neck with involvement of the greater tuberosity and 4-part valgus impacted fractures. Use of CRPP in PHFs is less invasive, allowing respect of soft tissues and blood supply during the surgical procedure(19). Compared to open reduction and internal fixation (ORIF), CRPP potentially has lower rates of avascular necrosis (AVN), higher union rates, less scar formation at the scapulo-thoracic joint and better cosmetics(20,21)

This technique utilizes image intensifier-guided closed manipulation or mini-open fracture reduction by means of 'joystick' pins, followed by fixation with a constellation of threaded pins to confer stability[13].Its main advantages include soft-tissue preservation, cosmesis, reduced blood loss and postoperative pain. Disadvantages include possibility of axillary nerve injury during percutaneous pin insertion[14,15], fixation failure[16], intra-articular pin migration during fracture collapse leading to re-operation and need for elective removal of metalwork(17).Herscovici et al[29] have also demonstrated a 100% failure rate with smooth Kirschner wires and recommend the use of threaded pins.Percutaneous wiring generally utilizes a starting point just above the deltoid insertion, where 2 threaded wires are directed proximally into the humeral head. Next, using a starting point on the greater tuberosity, 2 additional threaded wires are directed distally into the humeral shaft (Figure 2).

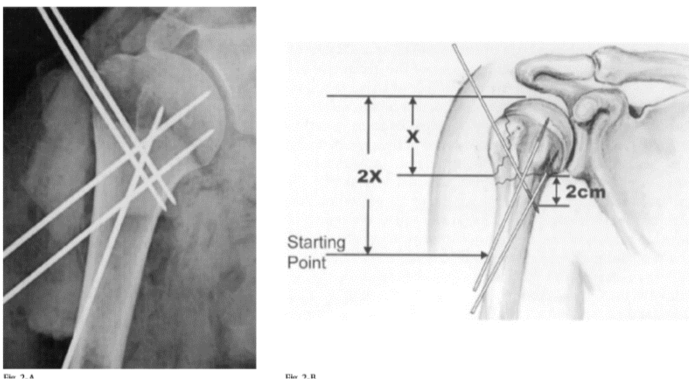


Fig. 2-A Anteroposterior radiograph showing the proximal part of the humerus with percutaneous pin placement as described by Jaberg et al.113. (Reproduced from: Rowles DJ, McGrory JE. Percutaneous pinning of the proximal part of the humerus. An anatomic study. J Bone Joint Surg Am. 2001;83:1696.) Fig. 2-B The safe starting point for the proximal lateral pins and the end point for the greater tuberosity pins. X = distance from the superiormost aspect of the humeral head to the inferiormost aspect of the humeral head. 2X = the starting point for the proximal lateral pin. The end point for the greater tuberosity pin should be >2 cm from the inferiormost margin of the humeral head.

Nonthreaded wires can be used to manipulate the fracture site prior to fixation with threaded wires. Specific techniques are described for valgus angulated fractures by Seyhan et al34 and varus angulated fractures by Eid et al.35 Althoughtechnically demanding, the results are excellent with ConstantMurley scores of 90 to 94 at 1-3 years follow-up.

Resch et al.8 described a technique for closed reduction and percutaneous fixation of three and four-part proximal humeral fractures. For three-part fractures, the subcapital fracture is reduced with adduction, internal rotation, and axial traction on the arm. A pointed hook retractor is inserted into the subacromial space to manipulate the greater tuberosity fragment anteriorly and inferiorly into anatomic position. Under image intensification, the shoulder is brought through internal and external rotation to confirm reduction of the greater tuberosity and two cannulated self-tapping 2.7-mm screws are used to fix the fragments. fig-3

Figure 3. Preoperative and postoperative X-rays illustrating a 2-part greater tuberosity fracture reduced with 2 lag screws.

This technique works well for large fragments, but small fragments may be more stable with suture fixation Brunner et al[18] have shown successful maintenance of reduction in 91% of 58 displaced proximal humerus fractures treated with the "humerus block". On the other hand, some authors stated that transcutaneous pinning has numerous complications such as unstable fixation, pin track infection, skin irritation, ahigh incidence of pin migration, and massive X-ray exposure; furthermore the surgical technique is also quite demanding (18).

Closed or open reduction and intramedullary nailing:

Nails are usually inserted anterogradely through a small proximal incision and locked percutaneously. As such, they allow preservationof the periosteal blood supply and surrounding soft tissue envelope, whilst their intramedullary position confers greater stability than other minimally invasive fixation techniques.A number of studies using a range of intramedullary nails have produced good results with union rates between 96% and 100%[22,23] in patients with two- and three-part fractures.Intramedullary nails can be used in surgical neck fractures, but the starting point is often compromised in 3-part fractures. The nail starting point is slightly medial to the greater tuberosity and cuff tendon insertions. It's preferable to go through the supraspinatus muscle belly at the lateral edge of the articular surface instead of splitting the tendon.(24)

clinical outcomes in 2 and 3-part PHFs treated with third generation humeral nails.51-54 In a retrospective study on 38 patients with 2-part surgical neck PHFs treated with locked angular stable intramedullary nail, Hatzidakis et al.reported 100% primary healing, a mean Constant score of 71 points and a mean forward flexion of 132° with little residual shoulder pain.55 However, Nolan et al. reported a high complication rate in 18 patients with 2 and 3-part PHFs treated with Polarus nail.(25) In a systematic review including 2155 patients (66 studies) treated with different modalities for PHFs, Lanting et al.reported 11.9% complication rate for IMN. The incidence of nonunion or malunion was 5%, implant loosening or migration 3.2% and osteonecrosis 4.5% (19.2% in 3 and 4-part fractures).

Some technical tips should be observed when nailing a PHF, especially in osteoporotic bone. The supraspinatus should be split at the lateral edge of the articular surface through the muscle belly instead of splitting the tendon. The entry point must be at the center of the humeral head, so that the stability of the fixation doesn't rely exclusively on the proximal screws, but is favored by the subchondral bone-nail interface, where the bone remains of better quality in comparison with other areas of the humeral head. The superior resistance to varus forces, obtained with the interference of the nail with the subchondral bone, is particularly important in osteoporotic fragility fractures, in which the weak cancellous bone of the medial calcar cannot ensure a reliable stability of the proximal screws.5,68 If these principles are not respected, a high failure rate should be expected. (Figure 4,5)

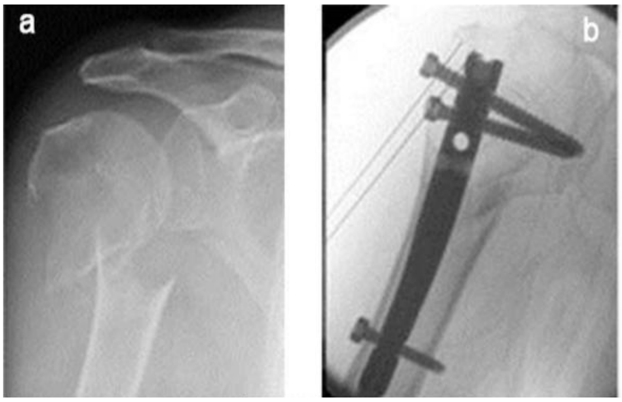


Fig-4-Polarus nail

Fig-5- Diphos nail Polyaxial

Intramedullary techniques preserve periosteal blood supply and retain surrounding soft tissue attachments. The short operating time, the limited exposure and soft tissue dissection, the short duration of hospitalization, and the rapid functional recovery are the advantages of the procedure, which can be used with good results in 2- and 3-part fractures. Absolute contraindication is fracture involving medial cortex and tuberosities.

Open reduction and internal fixation:Conventional Plate

Surgical Technique—Double-Plate Fixation Wanneret al.(41) used two one-third tubular plates to treat patients with two, three, or four-part proximal humeral fractures. A standard deltopectoral approach was used to gain access to the fracture. Lateral plate fixation to reduce the greater tuberosity was achieved first, typically with a five or six-hole one-third tubular plate. This was followed by fixation of a ventral plate at a 90° angle to the lateral plate. A four-hole one-third tubular plate with one proximal and one distal screw was usually used.The loosening and pull-out of screws are common reasons for failure(42).

Traditional plate constructs are usually reserved for young patients with an intact medial hinge, an adequate diaphyseal cortex (>4 mm), and no metaphyseal comminution. Patients who have osteoporosis or whose fracture lacks any of the above characteristics would likely benefit from locking-plate technology

Open reduction and internal fixation:
Locking plate

The extended deltopectoral approach remains the most commonly utilised exposure, despite its limited access to the lateral and posterior aspects of the proximal humerus[26]. An alternative extended deltoid-splitting approach has been described, with a view to improve access to the posterior aspect of the shoulder[27] through direct lateral[26] or anterolateral acromial incisions[42]. The anterior third of the deltoid may be reflected to allow greater exposure of the proximal part of the humerus. The rotator cuff tendons are tagged with multiple number-2 braided nonabsorbable sutures, whether as a part of a tuberosity fragment or in continuity with the head fragment. Fig(6,7).The tagging sutures are used to bring the tuberosity fragments in continuity with the lateral cortex of the shaft fragment, which may indirectly reduce the head fragment to the shaft. If the head fragment is impacted onto the shaft, a periosteal elevator can be inserted into the fracture site to disimpactthe head and thus restore the medial portion of the calcar. The plate should be positioned directly on the middle of the lateral cortex and approximately 8 mm distal to the superior aspect of the greater tuberosityto avoid lateral impingement.Provision of suture holes made it easy to repair the rotator cuff and provide stabilization of greater and lesser tuberosity fragment(PHILOS) [38,40].

Figure-6- PHILOS PLATE

Figure 8- 4-PART FRACTURE REDUCTION WITH PHILOS PLATE

A recent study by Buecking et al[28] has demonstrated no difference in complications, reoperations, fluoroscopy use, function and pain scoresbetween the extended deltoid-splitting and the anterior deltopectoral approach.Proximal humerus locking plates may provide reliable fixation in two-, three- and four-part fractures, as well as in some pathological fractures of the proximal humerus[29], particularly when used in conjunction with cement augmentation[30]. Application of the plate may facilitate indirect reduction of the distal diaphyseal fragment to the proximal parts, upon insertion of the working screw[29]. Through a combination of meticulous plate application and appropriately placed rotator cuff tendon fibre-wire suture loops, near anatomical indirect reduction of the tuberosities to the head and shaft fragments becomes possible, without additional soft tissue stripping and compromise to the blood supply[29]. Locking plates may also be used in conjunction with bone autograft, allograft[51-53], as well as devices such as the "Da Vinci System"[34]. Plate weakness isprimarily onthemedialside,andtherefore,specialattentionshouldbepaidtovarusangulation and medial comminution. These factors are associated with reduction loss. Bone void fillers, divergent screws, and medial calcar support (Figure 9) may prevent some of the complications associated with using plates in osteoporotic bone.(35)

Figure 9. Postoperative AP view of a 3-part fracture treated with a locking plate. Note the screw traversing the inferomedial humeral head, which is important for providing a medial support in the calcar region (dotted circle). With significant medial bone loss, graft material, fibular struts, or cement can be used to augment the construct. Tuberosities can be captured with screws or sutured to the plate. AP denotes anteroposterior.

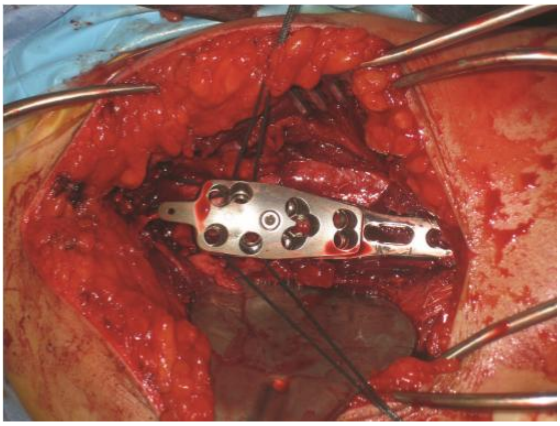


Figure 10-Intraop view- Tagging sutures are used to obtain reduction of the tuberosity fracture and then are passed through the suture holes in the proximal humeral locking plate.

Compared to the stiff implants (Humerus-T-plate, unreamed proximal humerus nail)the more elastic Locking Compression Plate Proximal Humerus showed a low load decrease with a low load level and a steady curve, which is promising for longterm stability (36).

Several important points need to be considered when using angular plates to stabilize proximal humerus fractures. Since the screws are inserted three-dimensional in the humeral head it is necessary to check the correct proximal position of every single screw separately by rotating the arm using an image intensifier. Primary screw perforations of the humeral head should be avoided (Fig. 11). Care has also to be taken not to insert the plate too far cranially to avoid impingement. If an adequate reduction is not achieved and medial buttressing is insufficient, especially in varusmalreduction, secondary loss of reduction and subsequent screw perforation or plate breakage is possible. The locking of the screws onto the plate prevents their backing out.

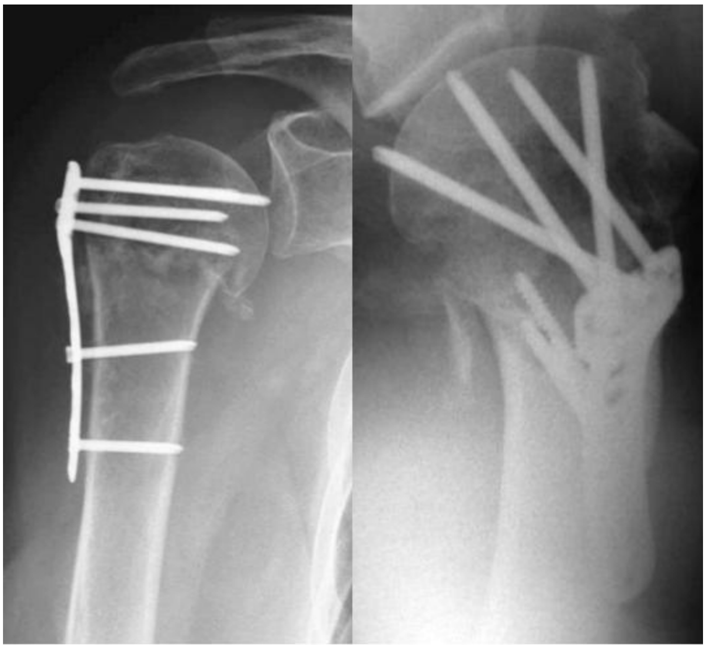


Figure 11. Complications after ORIF using Locking Proximal Humerus Plate. A primary screw perforation of the humeral head was seen on the postoperative AP and axial radiograph.

As suggested by Krappinger.et.al correct alignment of the medial cortices and anatomic reduction are the most important prognostic factors to avoid secondary displacement.(37)

Siffri P C et al. in their cadeveric study suggested that locking plates had better torsional stability compared to non-locking plates [38].In order to achieve optimum fixation and achieve maximum stability the implant should be of low profile, preferably anatomical in shape with provision of locking screws and additional holes for repair and restoration of rotator cuff anatomy. The provision of convergent and divergent screws provided additional stability in presence of comminution and osteoporosis.

Proper placement of calcar screw is a must to prevent varuscollapse.(fig-12)

Fig-12 shows Varus Collapse

As suggested by Padegimaset al.,the calcar screw should be positioned < 12 mm from the apex of the arc of the calcar or within the bottom 25% of the humeral head. Within these cut-offs, the incidence of fixation failures was significantly reduced in their clinical series.(39)

Open reduction and internal fixation with locked-plate fixation is contraindicated in some fracture-dislocations, headsplitting fractures, and impression fractures that involve >40% of the articular surface(26)

Study	Type of fixation	Constant score	Neer's classification
Kuchle et al (2006)	Cloverlaef plate	72.4	2,3& 4 part fracture
Ketter et al (2006)	Angle stable humerus plate	70.0	2,3&4 part fracture
Lill et al (2003)	Angle stable humerus plate	72.5	2,3&4 part fracture
Kollig et al (2003)	T palte, screws & k wires	72.1	3 & 4 part fracture
Wijgman et al (2002)	Classic T Plate cerclage	80.0	3 & 4 part fracture
Gerber et al	Internal fixation	78	2,3,& 4 part fracture
Hessman et al	T plate	69	2,3,& 4 part fracture

Table 1-Functional scores achieved with different treatment options for proximal humeral fractures in the current literature

Hemiarthroplasty;

Hemiarthroplasty is the most commonly used replacement option[44] (Figure 1B). It is indicated in non-reconstructible four-part fractures, fracture-dislocations and head-splitting fractures and for the revision of failed reconstructions, provided the tuberosities remain intact. A systematic review of 808 patients revealed a mean Constant score of 57 with significant functional limitations (106elevation and 92 abduction) but few reports of pain.(45) The technique is technically challenging and requires a functional rotator cuff with good reduction of the tuberosities. To maximize the probability of an optimal outcome, surgeons should pay particular attention to two important goals: restoring the tuberosities to an anatomical position, and placing the humeral component in the correct amount of version.Active infection of the shoulder joint and/or the surrounding soft tissue is an absolute contraindication to hemiarthroplasty. Open reduction and internal fixation should be considered in younger patients, particularly those with good bone stock, even when the fracture pattern is complicated.The mean head-to-tuberosity distance (and standard deviation) should be 8 ± 3 mm as shown by Frankle et al. and Mighellet al.(46).Excessive retroversion of the prosthesis is associated with joint dislocation [46] and failure of the tuberosities to unite.A recent systematic review of hemiarthroplasty for fractures reported a mean post-operative forward flexion of 105°, abduction 92° and Constant score of 56 [47].

Figure-13

Reverse polarity total shoulder arthroplasty:

Reverse polarity total shoulder arthroplasty was originally designed to treat glenohumeral arthritis with rotator cuff arthropathy[48].

Results from RTSA are promising. A 2013 systematic review concluded RTSA outcomes are superior to HA outcomes,73 whereas an early 2014 systematic review found improved forward flexion in RTSA but decreased external rotation.(49).A recent 2016 study by Grubhofer et al included 51 patients with 3 years of follow-up who demonstrated Constant scores at 86% of the contralateral shoulder.(50)(fig 14)An important pre-requisite, however, to performing reverse arthroplasty for fractures is to ensure that the axillary nerve is functioning prior to surgery as denervation of the deltoid would result in limited function.

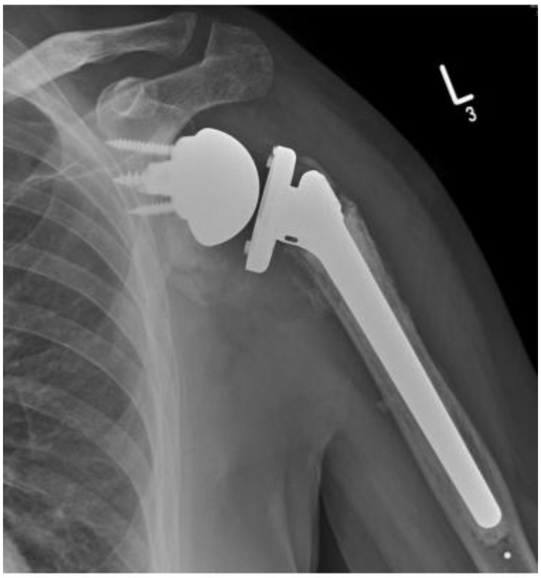


Fig-14

The complication rate is high including neuropraxia (11.6%), reflex sympathetic dystrophy (7%), anterior dislocation (2.3%), displacement of tuberosities (44.2%) andscapular notching (23.2%)(51).Notching can be prevented by proper placement of the glenoid component.Nevertheless, reverse polarity total shoulder arthroplasty remains a good option for independent elderly patients with non-reconstructible fractures and associated cuff deficiency.

V. Discussion

A multi-disciplinary team approach should be utilised with experienced musculoskeletal radiologists, geriatricians and specialised physiotherapists for optimal rehabilitation. A majority of minimally displaced fractures can be treated conservatively with early physical therapy.There is at present not enough evidence to suggest superiority of one treatment option over the others. With internal fixation, special attention should be paid to medial comminution, varus angulation, and restoration of the calcar. With arthroplasty, attention should be paid to anatomic restoration of the tuberosities and proper placement of the prosthesis.

CONFLICT OF INTEREST

The authors received no financial contributions to the work reported and no other potential conflict of interest exists

References

[1]. GAEBLER, C., McQUEEN, M. M., COURT-BROWN, C. M.: Minimally displaced proximal humeral fractures: epidemiology and outcome in 507 cases. Acta orthop. scand., 74: 580–5, 2003

[2]. KOVAL, K. J., GALLAGHER, M. A., MARSICANO, J. G., CUOMO, F., MCSHINAWY, A., ZUCKERMAN, J. D.:Functional outcome after minimally displaced fractures of the proximal part of the humerus. J. Bone Jt Surg., 79-A: 203–7, 1997.

[3]. ZYTO, K.: Non-operative treatment of comminuted fractures of the proximal humerus in elderly patients. Injury, 29: 349–52, 1998.

[4]. Agudelo J, Schurmann M, Stahel P, Helwig P, Morgan SJ, Zechel W, Bahrs C, Parekh A, Ziran B, Williams A, Smith W (2007) Analysis of efficacy and failure in proximal humerus fractures treated with locking plates. J Orthop Trauma 21(10):676–681.

[5]. Egol KA, Ong CC, Walsh M, Jazrawi LM, Tejwani NC, Zuckerman JD (2008) Early complications in proximal humerus fractures (OTA Types 11) treated with locked plates. J Orthop Trauma 22(3):159–164. https ://doi.org/10.1097/BOT.0b013 e3181 69ef2 a

[6]. Solberg BD, Moon CN, Franco DP, Paiement GD (2009) Locked plating of 3- and 4-part proximal humerus fractures in older patients: the effect of initial fracture pattern on outcome. J Orthop Trauma 23(2):113–119. https ://doi.org/10.1097/BOT.0b013 e3181 9344b f

[7]. KOUKAKIS, A., APOSTOLOU, C. D., TANEJA, T., KORRES, D. S., AMINI, A.: Fixation of proximal humerus fractures using the PHILOS plate: early experience. Clin. orthop., 442: 115–20, 2006

[8]. STROHM, P. C., HELWIG, P., KONRAD, G., SUDKAMP, N. P.: Locking plates in proximal humerus fractures. Acta Chir. orthop. Traum. čech., 74: 410–5, 2007.

[9]. Heather A.Vallier.MD.. Treatment of Proximal Humerusfractures.*JOrthop trauma* 2007;21:469-476

[10]. HELMY, N., HINTERMANN, B.: New trends in the treatment of proximal humerus fractures. Clin. orthop., 442:100–8, 2006.

[11]. HESSMANN, M., GEHLING, H., GOTZEN, L.:[Proximal humerus fracture in advanced age]. Langenbecks Arch. Chir. Suppl. Kongressbd., 113:907–9, 1996.

[12]. HROMÁDKA, R., POKORNÝ, D., POPELKA, S., JAHODA, D., SOSNA, A.: Three-dimensional geometry of the proximal humerus and rotator cuff attachment and its utilization in shoulder arthroplasty. Acta Chir. orthop. Traum. čech., 73: 77–84, 2006.

[13]. Naidu SH, Bixler B, Capo JT, Moulton MJ, Radin A. Percutaneous pinning of proximal humerus fractures: a biomechanical study. Orthopedics 1997; 20: 1073-1076 [PMID: 9397435]

[14]. Kamineni S, Ankem H, Sanghavi S. Anatomical considerations for percutaneous proximal humeral fracture fixation. Injury 2004; 35: 1133-1136 [PMID: 15488504 DOI: 10.1016/ j.injury.2003.08.008]

[15]. Rowles DJ, McGrory JE. Percutaneous pinning of the proximal part of the humerus. An anatomic study. J Bone Joint Surg Am 2001; 83-A: 1695-1699 [PMID: 11701793]

[16]. Herscovici D, Saunders DT, Johnson MP, Sanders R, DiPasquale T. Percutaneous fixation of proximal humeral fractures. Clin OrthopRelat Res 2000; (375): 97-104 [PMID: 10853158]

[17]. Brunner A, Weller K, Thormann S, Jöckel JA, Babst R. Closed reduction and minimally invasive percutaneous fixation of proximal humerus fractures using the Humerusblock. J Orthop Trauma 2010; 24: 407-413 [PMID: 20577070 DOI: 10.1097/BOT.0b013e3181c81b1c]

[18]. JABERG, H., WARNER, J. J., JAKOB, R. P.: Percutaneous stabilization of unstable fractures of the humerus. J. Bone Jt Surg., 74-A:508–15, 1992.

[19]. OA. Management of acute proximal humeral fractures. J Am AcadOrthopSurg2017;25:42-52.

[20]. Gumina S. Epidemiology of proximal humeral fractures: a detailed survey of 711 patients in a metropolitan area. J Shoulder ElbSurg2017;26:2117

[21]. Haldoll HH, Brorson S. Intervention for treating proximal humeral fractures in adult. Cochrane Db Syst Rev 2015; CD000434.

[22]. Giannoudis PV, Xypnitos FN, Dimitriou R, Manidakis N, Hackney R. "Internal fixation of proximal humeral fractures using the Polarus intramedullary nail: our institutional experience and review of the literature". J OrthopSurg Res 2012; 7: 39 [PMID: 23253302 DOI: 10.1186/1749-799x-7-39]

[23]. Sforzo CR, Wright TW. Treatment of acute proximal humerus fractures with a polarus nail. J SurgOrthop Adv 2009; 18: 28-34 [PMID: 19327263]

[24]. Dilisio MF, Nowinski RJ, Hatzidakis AM, Fehringer EV. Intramedullary nailing of the proximal humerus: evolution, technique, and results. J Shoulder Elbow Surg. 2016;25(5):e130-e138. doi: 10.1016/j.jse.2015.11.016

[25]. Nowinski GP. Surgical treatment of displaced proximal humerus fractures with a short intramedullary nail. J Shoulder ElbSurg2011;20:1241-7.

[26]. Robinson CM, Murray IR. The extended deltoid-splitting approach to the proximal humerus: variations and extensions. J Bone Joint Surg Br 2011; 93: 387-392 [PMID: 21357962 DOI: 10.1302/0301-620x.93b3.25818]

[27]. Robinson CM, Khan L, Akhtar A, Whittaker R. The extended deltoid-splitting approach to the proximal humerus. J Orthop Trauma 2007; 21: 657-662 [PMID: 17921842 DOI:10.1097/BOT.0b013e3180ce833e]

[28]. Buecking B, Mohr J, Bockmann B, Zettl R, Ruchholtz S. Deltoid-split or deltopectoral approaches for the treatment of displaced proximal humeral fractures? Clin OrthopRelat Res 2014; 472: 1576-1585 [PMID: 24326593 DOI: 10.1007/ s11999-013-3415-7]

[29]. Plecko M, Kraus A. Internal fixation of proximal humerus fractures using the locking proximal humerus plate. OperOrthopTraumatol 2005; 17: 25-50 [PMID: 16007377 DOI: 10.1007/s00064-005-1120-8]

[30]. Weiss KR, Bhumbra R, Biau DJ, Griffin AM, Deheshi B, Wunder JS, Ferguson PC. Fixation of pathological humeral fractures by the cemented plate technique. J Bone Joint Surg Br 2011; 93: 1093-1097 [PMID: 21768635 DOI: 10.1302/0301-6 20X.93B8.26194]

[31]. Russo R, Visconti V, Lombardi LV, Ciccarelli M, Giudice G. The block-bridge system: a new concept and surgical technique to reconstruct articular surfaces and tuberosities in complex proximal humeral fractures. J Shoulder Elbow Surg 2008; 17: 29-36 [PMID: 18069015 DOI: 10.1016/ j.jse.2007.03.027]

[32]. Gerber C, Werner CM, Vienne P. Internal fixation of complex fractures of the proximal humerus. J Bone Joint Surg Br 2004; 86: 848-855 [PMID: 15330026]

[33]. Gardner MJ, Boraiah S, Helfet DL, Lorich DG. Indirect medial reduction and strut support of proximal humerus fractures using an endosteal implant. J Orthop Trauma 2008; 22: 195-200 [PMID: 18317054 DOI: 10.1097/BOT.0b013e31815b3922]

[34]. Russo R, Visconti V, Lombardi LV, Ciccarelli M, Cautiero F. Da Vinci System: clinical experience with complex proximal humerus fractures. MusculoskeletSurg 2010; 94 Suppl 1: S57-S64 [PMID: 20383682 DOI: 10.1007/s12306-010-0066-7]

[35]. Jung S-W, Shim S-B, Kim H-M, Lee J-H, Lim H-S. Factors that influence reduction loss in proximal humerus fracture surgery. J Orthop Trauma. 2015;29(6):276-282. doi:10.1097/BOT. 0000000000000252.

[36]. LILL, H., HEPP, P., KORNER, J., KASSI, J. P., VERHEYDEN, A. P., JOSTEN, C. et al.: Proximal humeral fractures: how stiff should an implant be? A comparative mechanical study with new implants in human specimens. Arch. orthop. Trauma Surg., 123: 74–81, 2003.

[37]. Krappinger, Bizzotto N, Riedmann S, et al. Predicting failure after surgical fixation of proximal humerus fractures. Injury. 2011; 42:1283–8

[38]. Siffri PC, Peindl RD, Coley ER, Norton J, Connor PM, Kellam JF. Biomechanical Analysis of Blade Plate Versus Locking Plate Fixation for a Proximal Humerus Fracture: Comparison Using Cadaveric and Synthetic Humeri. J Orthop Trauma [Internet]. 2006 Sep [cited 2018; 20(8):547-54. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16990726

[39]. Padegimas EM, Zmistowski B, Lawrence C et al. Defining optimal calcar screw positioning in proximal humerus fixation. J Shoulder ElbSurg2017;26:1931-37.

[40]. Orthop A, Kilic B, Uysal M, Cinar BM, Ozkoc G, Demirors H et al. ACTA ORTHOPAEDICA et TRAUMATOLOGICA TURCICA Early results of treatment of proximal humerus fractures with the PHILOS locking plate Proksimalhumeruskırıkların PHILOS plağıiletedavisindeerkendönemsonuçlarımız [Internet]. TraumatolTurc. 2008 [cited 2018, 42]. Available from: http://aott.org.tr/files/journals/1/articles/1736/public/1736 -1938-1-PB

[41]. Wanner GA, Wanner-Schmid E, Romero J, Hersche O, von Smekal A, Trentz O, Ertel W. Internal fixation of displaced proximal humeral fractures with two onethird tubular plates. J Trauma. 2003;54:536-44.

[42]. Cornell CN. Internal fracture fixation in patients with osteoporosis. J Am AcadOrthop Surg. 2003;11:109-19

[43]. Mighell MA, Kolm GP, Collinge CA, Frankle MA. Outcomes of hemiarthroplasty for fractures of the proximal humerus. J Shoulder Elbow Surg. 2003;12:569-77.

[44]. Brorson S, Rasmussen JV, Olsen BS, Frich LH, Jensen SL, Hróbjartsson A. Reverse shoulder arthroplasty in acute fractures of the proximal humerus: A systematic review. Int J Shoulder Surg 2013; 7: 70-78 [PMID: 23960366 DOI: 10.4103/0 973-6042.114225]

[45]. Kontakis G, Koutras C, Tosounidis T, Giannoudis P. Early management of proximal humeral fractures with hemiarthroplasty: a systematic review. J Bone Joint Surg Br. 2008;90(11):1407-1413. doi:10.1302/0301-620X.90B11.21070.

[46]. Mighell MA, Kolm GP, Collinge CA, Frankle MA. Outcomes of hemiarthroplasty for fractures of the proximal humerus. J Shoulder Elbow Surg. 2003;12:569-77.

[47]. Kontakis G, Koutras C, Tosounidis T, Giannoudis P. Early management of proximal humeral fractures with hemiarthroplasty: a systematic review. J Bone Joint Surg Br 2008; 90(11): 1407-13

[48]. Baulot E, Sirveaux F, Boileau P. Grammont's idea: The story of Paul Grammont's functional surgery concept and the development of the reverse principle. Clin OrthopRelat Res 2011; 469: 2425-2431 [PMID: 21210311 DOI: 10.1007/s11999010-1757-y]

[49]. Ferrel JR, Trinh TQ, Fischer RA. Reverse total shoulder arthroplasty versus hemiarthroplasty for proximal humeral fractures: a systematic review. J Orthop Trauma. 2015;29(1):60-68. doi:10. 1097/BOT.0000000000000224.

[50]. Grubhofer F, Wieser K, Meyer DC, et al. Reverse total shoulder arthroplasty for acute head-splitting, 3- and 4-part fractures of the proximal humerus in the elderly. J Shoulder Elbow Surg. 2016; 25(10):1690-1698. doi:10.1016/j.jse.2016.02.024.

[51]. Cazeneuve JF, Cristofari DJ. The reverse shoulder prosthesis in the treatment of fractures of the proximal humerus in the elderly. J Bone Joint Surg Br 2010; 92: 535-9.

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