

RESEARCH ARTICLE

The Outcome of Proximal Humeral Locking Plates in the Management of Three and Four Part Proximal Humeral Fractures in Special Cohort of Young Patients in High Velocity Trauma

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Abstract

Background: Locking plate fixation provides satisfactory outcome following proximal humerus fractures. None of the previous studies selectively evaluate the outcome in young patients. This study evaluates outcome of locking plate system in the treatment of acute three- and four-part fractures in young patients.

Methods: In this prospective study we included all patients who were less than 60 years, involved in high velocity trauma, had proximal humerus comminuted three part and four part fractures and were operated using locking plate at our centre, between August 2011 to August 2015. All the patients were followed up regularly. Assessment was done clinically using Constant and Murley scoring system and radiologically using signs of healing in the form of callus formation and cortical continuity.

Results: Twenty-five eligible patients were operated during the study period. All patients were involved in motor vehicle collision. Average age of our patients was 41.2. The average duration of follow-up was 18.2 months (8 months to 27 months). 24 out of 25 fractures united clinically and radiologically at three months' follow-up. Average Constant and Murley score at final follow-up was 78.52. The results were excellent to good in 15 patients, fair in five patients and poor in five patients. Overall complication rate was 24%. Majority of them (20%) were restriction of movements of shoulders. None of our patients needed reoperation.

Conclusion: Locking plate system, in three part and four part proximal humerus fractures in young patients, provides secure and stable fracture fixation for early mobilization. Early results with locking plate system were promising in younger patients. In these patients, locking plate system has definite role to preserve the humeral head and there by maintain the functional activity level.

Level of evidence: III

Keywords: Locking plate, Proximal humerus fractures, Shoulder, Young patients

Introduction

Fractures of the proximal humerus are common and debilitating injuries and have bimodal age distribution. In old patients it is often due to low energy injury (1, 2). However, in young patients proximal humerus fracture is often due to high energy

trauma and is associated with severe comminution (3). Complications following proximal humerus fracture and management can be broadly classified as ones due to the fracture itself and ones due to the management options. Complications like stiffness, avascular necrosis

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and secondary osteoarthritis are often related to the severity of the fracture. Complications like malunion, implant failure and non-union are often related to the treatment option chosen (4-10). Proponents of locking plate fixation often cite better fixation, early mobilization, head preservation, restoration of range of motion and satisfactory function as some of the major advantages of locking plate construct. Proponents of prosthetic replacement often quote predictability in terms of pain relief as the major advantage but prosthetic replacement often fails to provide necessary function, stability and range of motion in young active patients and hence not a suitable option in this group of patients.

Various authors have reported their experience with locking plate in the management of proximal humerus fractures. But most of these reports fail to selectively evaluate the outcome in the difficult cohort of young patient with comminuted three part and four part proximal humerus fracture. In this prospective study we tried to evaluate the merits and demerits of proximal humeral locking plate system in the treatment of acutely displaced three- and four-part fractures of the proximal humerus in young age group with high velocity trauma.

Materials and Methods

This prospective longitudinal study was conducted at a tertiary care centre in Tamilnadu, India. Inclusion criteria is summarized in table 1. Undisplaced fractures, two- part fractures, pediatric patients, pathological fractures, low velocity injuries and patients with age more than 60 years were excluded.

An institutional review board approval was obtained for this prospective study. A standardized pathway was utilized in the management of these patient perioperatively. Data was collected prospectively. Data regarding demographics of the patients, mode of injury, physical examination findings, Xrays (antero posterior and axillary radiographs) and CT scans were collected and documented. Preoperative radiographs were classified using the Neer's classification system to grade the fractures (11). All patients were taken up for surgery after optimization of medical conditions as appropriate. All surgeries were performed by the same trauma team involving two senior orthopaedic

Table 1. Inclusion criteria

Inclusion criteria	
Age	18 to 60 years
Mechanism of injury	High velocity trauma
Neer's classification of fracture	Three part and four part fractures
Management	Fixation using proximal humeral locking plate
Time period in which the fracture and management happened	August 2011 to August 2015

Table 2. Results based on Constant and Murley scoring system

Total score	Result
100-90	Excellent
80-89	Good
70-79	Fair
0-70	Poor

surgeons. A general anaesthesia was used in all patients. Deltopectoral approach was used in all patients. The fracture fragments were first reduced and fixed provisionally with k-wires. Plate positioned laterally and provisionally secured to the head with k-wires and then plate fixed with appropriate size screws. The whole procedure was monitored under image intensifier control. Rotator cuff was repaired. The stability of fracture fixation was tested before wound was closed with drains. Post operatively intravenous antibiotics was given for 48 hours and wound checked on second post-operative day. Routine postoperative radiographs were obtained in all patients before discharge. Follow-up radiographs were also obtained at one month, three months and at six months on all patients. Standardized rehabilitation protocol was implemented in all patients and pendular movements were started from the second post-operative day. Active assisted exercises were started after 10 days and active exercises were started at four weeks. All the patients were followed up regularly once in a month for first three months, once in three months for next six months and once in six months thereafter.

Assessment of shoulder function was done using Constant and Murley scoring system (3) at three months, six months, one year and at final follow-up [Table 2]. Radiological signs of healing in the form of callus formation and cortical continuity were assessed in the three months and six months' follow-up radiographs. Radiographs were also used to check for complications including implant failure, secondary screw penetration and avascular necrosis.

Compliance with Ethical Standards

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

Results

Twenty-five eligible patients were operated during the study period from August 2011 to August 2015. Out of twenty-five, 18 were males and 7 were females. All patients were involved in a motor vehicle collision. Average age of our patient was 41.2 [Figure 1].

The average duration of follow-up was 18.2 months

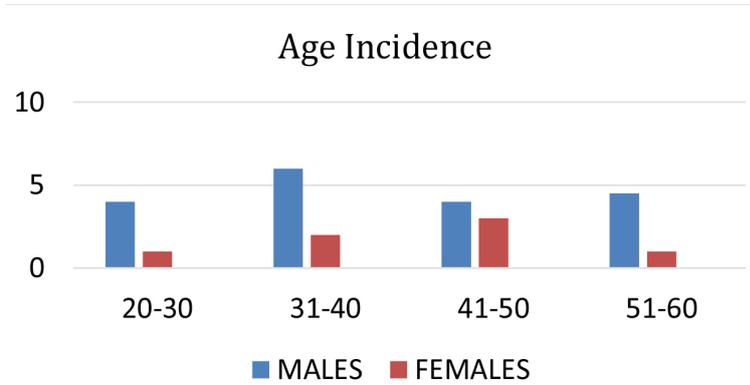


Figure 1. Age and sex incidence.

Percentage of Incidence

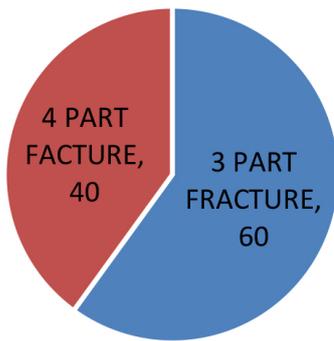


Figure 2. Incidence of three part and four part fractures in the study group.

(Range: 8-27 months). There were 15 (60%) three-part fractures and 10 (40%) four-part [Figure 2].

One patient with three-part fracture had associated shoulder dislocation. All fractures were of closed types. 24 out of 25 fractures united clinically and radiologically at three months' follow-up. One delayed union occurred in the patient with three-part fracture dislocation which eventually united at the end of 20 weeks. Average Constant and Murley score at final follow-up was 78.52 [Figure 3].

Average score for patients with three part fracture was 82.40 and average score for four part fracture was 72.70. The results were excellent to good in 15 patients, fair in five patients and poor in five patients [Figure 4].

Overall complication rate in our study was 24%. Majority of them, five patients (20%), were restriction of movements of shoulders. Three out of five patients had functional range of motion not requiring any additional procedures. Remaining two patients were

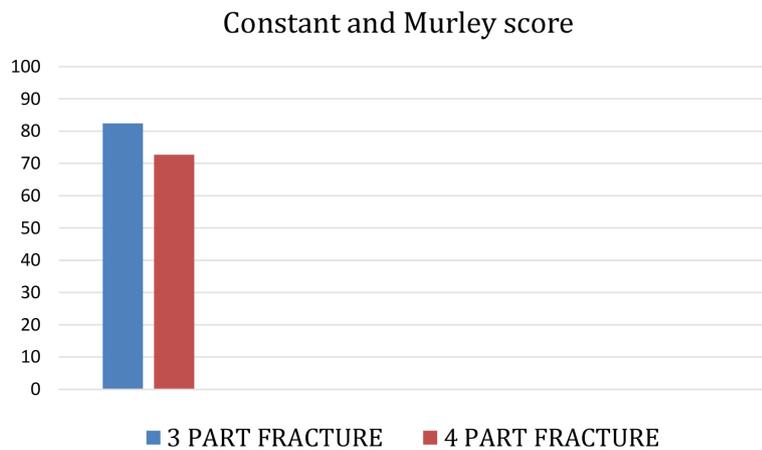


Figure 3. Constant and murley score in three part and four part fractures.

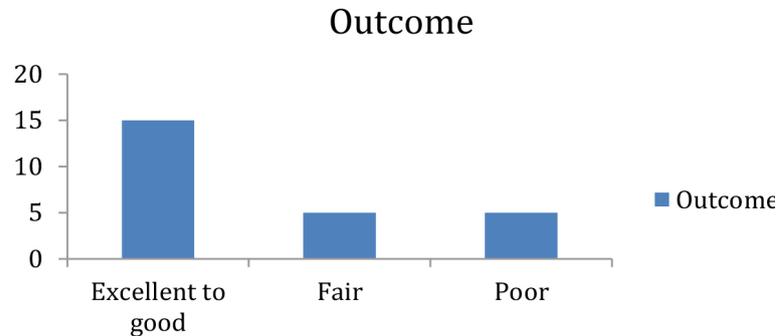


Figure 4. Outcome of our study.

offered surgical management but patients refused because of overall satisfactory pain relief and function. Other complications noted were osteonecrosis in one patient, delayed union in one patient, painful impingement in one patient. None of our patients needed reoperation for loss of reduction, primary or secondary screw penetration or soft tissue complications. Patient with radiological evidence of osteonecrosis had good functional outcome and hence he elected to continue with non-operative care.

Discussion

Fractures of the proximal humerus were first described by Hippocrates way back in 420 B.C. In 1970, Neer classified proximal humerus fractures based on number of fracture fragments that are displaced (11). AO/OTA group came with an alternative classification based on the location of fracture and the status of the surgical neck of humerus which reflect the blood supply to the humeral head (12).

Majority of patients, 80 – 90%, with proximal humerus fractures can be managed conservatively without surgery. Most of these fractures are minimally displaced ones and had high union rates (13).

Closed reduction and percutaneous fixation is mainly indicated for two part fractures and some minimally

displaced three part fractures. Some studies have reported good results with closed reduction and percutaneous fixation. This procedure is technically demanding and has a substantial learning curve (14, 15).

Biomechanical studies comparing locking plates versus non locking plates for open reduction and internal fixation of displaced proximal humerus fractures reported many biomechanical advantages, increased torsional and pull out strength, and less complication rate to locking plates as compared to non-locking plates (16, 17). Proponents of locking plate fixation often cite better fixation, early mobilization, head preservation, restoration of range of motion and satisfactory function as some of the major advantages of locking plate construct (18-25). Details of the selected hallmark studies of locking plate fixation for proximal humeral fractures are compiled in Table 3. In a negatively selected case series by Jost et al complications occurred were malreduction, primary screw cutout, malunion, nonunion, avascular necrosis, and infection (26).

The outcome of the intramedullary nailing for the treatment of proximal humerus fractures was quite unpredictable. The choice of site of entry can be difficult and it may cause lateral metaphyseal comminution (27).

Immediate stability and pain relief was mentioned

Table 3. Selected studies on proximal humeral locking plate

Author	Published year	No. Of cases	Type of fracture	Mean Age	Outcome Constant and Murley scoring
Bjorkenheim et al (19)	2004	72	Two part three part and Four part	67	72
Koukakis et al (20)	2006	20	Two part three part and Four part	71	76.1
P.Moonot et al (21)	2007	32	Three part and Four part	60	66.5
Thanasas C et al (22)	2009	Systematic review of 791 patients	Three part and Four part	NA	74.3
P Clavert et al	2010	73	Three part and Four part	65	62.3
Olerud P et al.(18)	2011	60	Unstable Three part	74	61
Konigshausen et al	2013	73	Three part and Four part	69.9	66.6
Chodavarapu LM et al	2016	30	Two part three part and Four part	40.4	76

Table 4. comparison of our study versus moonot et al study

	Our study	Moonot et al
Type of fracture	Acutely displaced three part and four part proximal humerus fractures	Acutely displaced three part and four part proximal humerus fractures
No. of cases	25. Three part (15) Four part(10)	32. Three part (20) Four part (12)
Mode of injury	Motor vehicle collision(25)	Simple fall (23) Accident (6) Fell from staircase (3)
Type of fracture	Closed	Closed
Outcome At 3 months follow up	24 out of 25 cases united clinically and radiologically	31 out of 32 cases united clinically and radiologically
Delayed union	One	Nil
Non union	Nil	One
Malunion	Nil	Two
Infection	Nil	One (superficial infection)
Impingement	One	Three
Re operation for impingement	Nil	Two
Avascular necrosis	One	One
Screw breakage	Nil	One (distal screw)
Frozen shoulder	Five	NA
Mean age group	41.2	59.9
Average Constant and Murley score	78.52	66.5

as the benefits of shoulder hemiarthroplasty. But the unpredictable functional outcome and associated complications like tuberosity nonunion, heterotopic ossificans, proximal migration of prosthesis, infection, nerve injuries and glenoid wear and tear make the surgery limited to particular indications only (11, 28, 29). Reverse shoulder arthroplasty reported comparable functional outcomes to other surgical techniques. Firm conclusions cannot be drawn until both longer follow up is available and randomized controlled trials compare this modality against other primary treatments (30- 32).

Overall, surgeons reporting the outcome following proximal humeral locking plate fixation for proximal humerus fracture is very limited with isolated case reports in mixed group of patients. We think that the trauma surgeons utilizing this implant in considerable volume should continue to report their findings in different age groups of patients. We studied the outcome of locking plate fixation in three part and four part proximal humerus fractures in patients aged less than 60 years, with an average age 41.2 years. Various authors have reported their experience with locking

plate in the management of proximal humerus fractures in elderly patients (18-26). However, most studies are isolated case series with majority of patients having osteoporotic proximal humerus fracture. In contrast, in this prospective study, we tried to evaluate the merits and demerits of Proximal Humeral locking plate system in the treatment of acutely displaced three- and four-part fractures of the proximal humerus in young age group with high velocity trauma.

Our study of patients with three- and four- part proximal humerus fractures, treated with proximal humeral locking plate system is compared with the study by Moonot *et al.* (21) which treated only three- and four-part proximal humerus fractures, in which 32 patients were treated by open reduction and internal fixation with locking plate system [Table 4].

In our study, average Constant and Murley score at final follow-up was 78.52. Average score for patients with three-part fracture was 82.40 and average score for four-part fracture was 72.70. The results were excellent to good in 15 patients (60%), fair in five (20%) patients and poor in five (20%) patients. In Moonot *et al* study, 15 (47%) patients had excellent results, 12(37%)



Figure 5. Comminuted four part fracture in a 40 year old man.

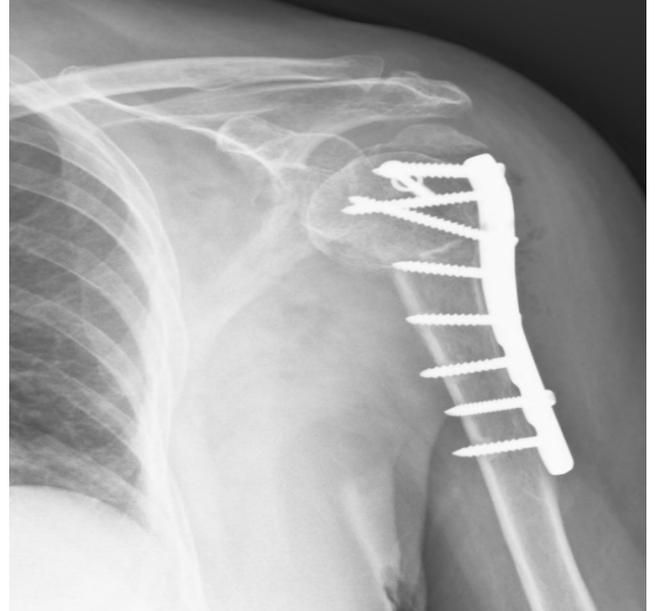


Figure 6. Post-operative x-rays of the patient in the Figure 5, after three months follow up.



Figure 7 and 8. Clinical photographs of the patient in figure 5 and 6, showing good functional range of movements.

patients had satisfactory and five (16%) patients had poor results. The mean Constant score in this study was 66.5. The better outcome and less complication rate in our study as compared to the study done by Moonot *et al* was attributed to the young age and good bone quality of our study population. In Moonot *et al* study a total of

18 (56%) patients were aged more, and 14 (44%) less than 60 years with mean age of 59.9 years. The youngest patient age was 18 years' age and oldest patient age was 87 years.

Early results with locking plate system were promising in young patients. In young patients with complex three

and four-part fracture, proximal humeral locking plate system has definite role to preserve the humeral head and there by maintain the functional activity level.

Proximal humeral locking plate system in three part and four part fractures in young peoples, provides secure and stable fracture fixation for early mobilization. Early results with proximal humeral locking plate system were promising in younger patients. In these patients, locking plate system has definite role to preserve the humeral head and there by maintain the functional activity level.

“The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.”

Limitations

The limitations in our study include a small sample size, a single mode of injury (accident) and fracture fixation methods (only locking plate was described). The small sample size in our study has an impact

on the analysis of outcomes, as it can overestimate the results. Furthermore, the study involves fracture fixation with locking plate alone and other fixation methods could have also been used for comparison of various fixation methods in proximal humerus fractures.

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References

1. Court-Brown CM, Garg A, McQueen MM. The epidemiology of proximal humeral fractures. *Acta Orthop Scand.* 2001; 72(4):365-71.
2. Green A, Norris T. Proximal humerus fractures and fracture dislocations. Philadelphia: Saunders; 2003. P. 1532-624.
3. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res.* 1987; 214:160-4
4. Brunner F, Sommer C, Bahrs C, Heuwinkel R, Hafner C, Rillmann P, et al. Open reduction and internal fixation of proximal humerus fractures using a proximal humeral locked plate: a prospective multicenter analysis. *J Orthop Trauma.* 2009; 23(3):163-72.
5. Gardner MJ, Lorich DG, Werner CM, Helfet DL. Second-generation concepts for locked plating of proximal humerus fractures. *Am J Orthop (Belle Mead NJ).* 2007; 36(9):460-5.
6. Hall JA, Phieffer LS, McKee MD. Humeral shaft split fracture around proximal humeral locking plates: a report of two cases. *J Orthop Trauma.* 2006; 20(10):710-4.
7. Khunda A, Stirrat AN, Dunlop P. Injury to the axillary artery, a complication of fixation using a locking plate. *J Bone Joint Surg Br.* 2007; 89(11):1519-21.
8. Smith AM, Mardones RM, Sperling JW, Cofield RH. Early complications of operatively treated proximal humeral fractures. *J Shoulder Elbow Surg.* 2007; 16(1):14-24.
9. Tolat AR, Amis A, Crofton S, Sinha J. Failure of humeral fracture fixation plate in a young patient using the Philos system: case report. *J Shoulder Elbow Surg.* 2006; 15(6):e44-7.
10. Voigt C, Woltmann A, Partenheimer A, Lill H. [Management of complications after angularly stable locking proximal humerus plate fixation. *Chirurg.* 2007; 78(1):40-6.
11. Neer CS 2nd. Displaced proximal humeral fractures. II. Treatment of three-part and four-part displacement. *J Bone Joint Surg Am.* 1970; 52(6):1090-103.
12. Müller ME, Allgöwer M. Manual of internal fixation: techniques recommended by the AO-ASIF group. Berlin, Germany: Springer Science & Business Media; 1991.
13. Gaebler C, McQueen MM, Court-Brown CM. Minimally displaced proximal humeral fractures: epidemiology and outcome in 507 cases. *Acta Orthop Scand.* 2003; 74(5):580-5.
14. Keener JD, Parsons BO, Flatow EL, Rogers K, Williams GR, Galatz LM. Outcomes after percutaneous reduction and fixation of proximal humeral fractures. *J Shoulder Elbow Surg.* 2007; 16(3):330-8.
15. Fenichel I, Oran A, Burstein G, Perry M. Percutaneous pinning using threaded pins as a treatment option for unstable two- and three-part fractures of the proximal humerus: a retrospective study. *Int Orthop.* 2006; 30(3):153-7.
16. Walsh S, Reindl R, Harvey E, Berry G, Beckman L, Steffen T. Biomechanical comparison of a unique locking plate versus a standard plate for internal fixation of proximal humerus fractures in a cadaveric model. *Clin Biomech (Bristol, Avon).* 2006; 21(10):1027-31.
17. Seide K, Triebe J, Faschingbauer M, Schulz AP, Püschel K, Mehrrens G, et al. Locked vs. unlocked plate osteosynthesis of the proximal humerus - a biomechanical study. *Clin Biomech (Bristol, Avon).*

- 2007; 22(2):176-82.
18. Olerud P, Ahrengart L, Ponzer S, Saving J, Tidermark J. Internal fixation versus nonoperative treatment of displaced 3-part proximal humeral fractures in elderly patients: a randomized controlled trial. *J Shoulder Elbow Surg.* 2011; 20(5):747-55.
 19. Björkenheim JM, Pajarinen J, Savolainen V. Internal fixation of proximal humeral fractures with a locking compression plate: a retrospective evaluation of 72 patients followed for a minimum of 1 year. *Acta Orthop Scand.* 2004; 75(6):741-5.
 20. Koukakis A, Apostolou CD, Taneja T, Korres DS, Amini A. Fixation of proximal humerus fractures using the PHILOS plate: early experience. *Clin Orthop Relat Res.* 2006; 442:115-20.
 21. Moonot P, Ashwood N, Hamlet M. Early results for treatment of three- and four-part fractures of the proximal humerus using the PHILOS plate system. *J Bone Joint Surg Br.* 2007; 89(9):1206-9.
 22. Thanasas C, Kontakis G, Angoules A, Limb D, Giannoudis P. Treatment of proximal humerus fractures with locking plates: a systematic review. *J Shoulder Elbow Surg;* 2009; 18(6):837-44.
 23. Clavert P, Adam P, Bevort A, Bonnomet F, Kempf JF. Pitfalls and complications with locking plate for proximal humerus fracture. *J Shoulder Elbow Surg.* 2010; 19(4):489-94.
 24. Königshausen M, Kubler L, Godry H, Citak M, Schildhauer TA, Seybold D. Clinical outcome and complications using a polyaxial locking plate in the treatment of displaced proximal humerus fracture. A reliable system? *Injury;* 2012; 43(2):223-31.
 25. Chodavarapu LM, Chowdojirao SK, Gonu A, Patnala C, Chilakamarri VK. Analysis of surgical fixation of displaced proximal humerus fractures using PHILOS plate. *Int J Res Orthop.* 2016; 2(4):245-50.
 26. Jost B, Spross C, Grehn H, Gerber C. Locking plate fixation of fractures of the proximal humerus: analysis of complications, revision strategies and outcome. *J Shoulder Elbow Surg.* 2013; 22(4):542-9.
 27. 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 Orthop Surg Res.* 2012; 7(1):39-48.
 28. 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
 29. Grönhagen CM, Abbaszadegan H, Révay SA, Adolphson PY. Medium-term results after primary hemiarthroplasty for comminuted proximal humerus fractures: a study of 46 patients followed up for an average of 4.4 years. *J Shoulder Elbow Surg.* 2007; 16(6):766-73.
 30. Bufquin T, Hersan A, Hubert L, Massin P. Reverse shoulder arthroplasty for the treatment of three- and four-part fractures of the proximal humerus in the elderly: a prospective review of 43 cases with a short-term follow-up. *J Bone Joint Surg Br.* 2007; 89(4):516-20.
 31. Klein M, Juschka M, Hinkenjann B, Scherger B, Ostermann PA. Treatment of comminuted fractures of the proximal humerus in elderly patients with the Delta III reverse shoulder prosthesis. *J Orthop Trauma.* 2008; 22(10):698-704.
 32. 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(4):535-9.