



COMPARATIVE EVALUATION OF RESULTS OF CLOSE REDUCTION AND EXTERNAL FIXATION VERSUS OPEN REDUCTION AND INTERNAL FIXATION WITH PLATE SCREW FIXATION FOR DISPLACED PROXIMAL HUMERUS FRACTURES IN ADULT

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ABSTRACT

To compare the clinicoradiological results of osteosynthesis by close reduction and external fixation & open reduction & internal fixation with plate screw fixation in the management of displaced proximal humerus fractures in adults in terms of bony healing & functional recovery of shoulder.

During the period of 24 months between March 2016 and Feb 2018 at the Orthopaedics department of I.P.G.M.E.R. & S.S.K.M. Hospital, a total of 30 cases with 15 cases by Closed Reduction & External Fixation and 15 cases by Open reduction & internal fixation in displaced proximal humerus fractures in adults were done.

Proximal Humerus fracture is most common in elderly people where bone is osteoporotic. In such bone implant holding capacity is less. Now Open Reduction & Internal fixation is gold standard for the treatment of Proximal humerus fractures. But it has many complications. So we chose Closed Reduction & External fixation for proximal humerus fractures to overcome the complications of Open reduction & internal fixation & compare the results between them.

Our study shows that operative time & fracture union time is significantly less in Closed reduction & external fixation(CREF). Complications are also less in case of Closed reduction & external fixation in compared to Open reduction & internal fixation(ORIF). Though the Final CMS score is more or less same in both groups but initially after surgery(upto 6 weeks) CMS score is significantly superior in Closed reduction & external fixation.

KEYWORDS

Close Reduction, External Fixation, Plate Screw Fixation, Proximal Humerus Fractures

INTRODUCTION

Proximal humeral fractures, defined as fractures occurring at or proximal to the surgical neck of the humerus. In the adult population, proximal humeral fractures have a unimodal distribution. The incidence of proximal humerus fractures fluctuates with ages.

Females have the highest risk of suffering a proximal humerus fracture¹. As with other osteoporosis-related fractures, additional risk factors for proximal humeral fractures include low bone mass and an increased risk of falls. Furthermore patients with poor vision, use of hearing aid, diabetes mellitus, depression, alcohol consumption, use of anticonvulsive medication, and a maternal history of hip fracture have been identified as being at increased risk of sustaining a proximal humeral fracture.

Proximal humeral fractures account for 4–5% of all fractures & 26% of Humerus fractures²; most of them involving elderly and osteoporotic people³. The 2:1 female to male ratio is likely related to issues of bone density as well⁴. 51% of such fractures are displaced. Fractures with minimal displacement, regardless of the number of fracture lines, can be treated with closed reduction and early mobilization.

Proximal humeral fractures pose an increased risk for subsequent distal radius and proximal femur fractures. Patients with proximal humeral fractures have a greater than 5 times risk of suffering a hip fracture within 1 year than matched pairs without proximal humeral fractures⁵. An increased risk for hip fracture however continues over the years, with a lifetime risk of suffering a hip fracture after a proximal humeral fracture is 16%, which is identical to that after distal radius fractures and 1.5 times higher than that of nonfractured patients⁵.

Approximately half of all proximal humeral fractures occur at home with the majority occurring as a consequence of falls on level ground⁶. In individuals 60 years or older, over 90% of proximal humeral fractures result from a fall from a standing height⁷. In younger individuals there is a higher incidence of proximal humeral fractures occurring outside the home, as a result of higher-energy trauma, such as a fall from a height, motor vehicle accidents (MVA), sports, or assaults.

The proximal humerus fracture can occur as a consequence of three main loading modes: compressive loading of the glenoid onto the humeral head, bending forces at the surgical neck, and tension forces of the rotator cuff at the greater and lesser tuberosities. When the glenoid

impacts on the humeral head during a fall in individuals with normal bone, the proximal humeral epiphysis appears to be able to resist local compressive loads. Apart from bone quality fracture configuration is influenced by the amount of kinetic energy conveyed to the shoulder, and by the position of the upper limb during injury. High-energy fractures in normal bone result in marked comminution of the surgical neck area with extension into the proximal humeral shaft with the integrity of the proximal humeral epiphysis usually being preserved.⁸⁻⁹

The range of treatment options for proximal humerus fractures consists of

1. Nonoperative therapy
2. Intramedullary nailing
3. Open reduction and plate fixation
4. Closed reduction & External fixation by percutaneous pinning
5. Primary arthroplasty.

Open reduction & plate fixation & Closed Reduction & External Fixation by percutaneous pinning are the two popular method for treatment of proximal humerus fractures. But there are many advantage & disadvantages of both of these procedures. Despite the advocates for each approach, the evidence regarding the relative effectiveness of Open reduction & plate fixation vs Closed Reduction & External Fixation by percutaneous pinning of Proximal Humerus fractures remains unclear so we decided to do a study comparing the efficacy and functional outcomes of the two procedures.

The Advantages of close reduction and external fixation⁸ are minimal invasion of tissue, lightweight and easy to handle, minimal OT duration & hence less duration anaesthesia exposure, early joints mobilization, no iatrogenic injury to vascular supply of head.

The disadvantages of close reduction & external fixation⁸ are its steep learning curve & risk of axillary nerve/vascular injury.

The advantages of open reduction & internal fixation⁸ are anatomic fracture reduction is possible, most stable method of fixation in multipart fractures.

The disadvantages of ORIF^{8,9} are increased risk of infection, increased risk of osteonecrosis, adhesion, frozen shoulder, rotator cuff lesion, primary & secondary screw perforation, loosening, screw backing out. Our aim is to compare the clinicoradiological results of osteosynthesis by close reduction and external fixation & open reduction

& internal fixation with plate screw fixation in the management of displaced proximal humerus fractures in adults in terms of bony healing & functional recovery of shoulder.

MATERIALS AND METHODS

- i. **STUDY POPULATION:** The patients coming to orthopaedics-OPD and emergency with fracture of proximal humerus was screened and recruited based on fulfillment of inclusion and exclusion criteria & choosed randomly for the procedure at the Orthopaedics department of I.P.G.M.E.R. & S.S.K.M. Hospital.
- ii. **Closed Reduction:** The patient's muscles must be completely relaxed so that the surgeon can manipulate the fracture fragments to obtain reduction. In many patients, the humeral shaft is either angulated with the apex anterior or completely displaced anteriorly as a result of the pull of the pectoralis major tendon. Reduction is performed by applying longitudinal traction with the arm in minimal abduction and some flexion. This position will relax tension on the pectoralis major, and posterior pressure on the humeral shaft may then reduce both displacement and angulation between the shaft and the humeral head fragments. 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.

Percutaneous Fixation with Pins:

Three pins at humeral head will be at 30° to each other in the same horizontal plane.

The 1st one just lateral to bicipital groove.

The 2nd one in true lateral plane

The 3rd one posterior to the central one.

The shoulder will be externally rotated during placement of the greater tuberosity pins so as to move the axillary nerve and the posterior circumflex artery farther away from the humeral neck.

Three pins will be inserted in the shaft of humerus distal to the fracture line which is equal to the distance from the superior most aspect of the humeral head to the inferior most aspect of the humeral head. in the same horizontal plane: Central one in true lateral plane, another one at 30° anteriorly, and the other one at 30° posteriorly.

STUDY PERIOD: 24 months between March 2016 and Feb 2018

Inclusion criteria:

1. Closed displaced 2/3/4 part fracture in adult (18-75 years)
2. Fracture of duration <3 weeks will be selected
3. Those willing to participate in the study

Exclusion criteria:

1. Patients with comorbid conditions not fit for surgery
2. Head split fracture & fracture dislocation
3. with extensive neurovascular injury
4. Pathological fracture
5. Old and neglected fractures (>3 weeks)
6. Undisplaced fracture

Postoperative care

A triangular sling will be applied for comfort

Alternate day pin tract dressing was done using Normal saline & ciprofloxacin or gentamycin eye drop.

Pendulum movement of the involved extremity encouraged from postoperative day one to three depending upon postoperative pain.

After 2 weeks all movement exercises were encouraged except abduction initially supine position, gradually to sitting and standing.

B. Open Reduction & Internal Fixation with plate:-

Done by conventional method

- iii. **SAMPLE SIZE:** In this prospective longitudinal study 30 patients with proximal humeral fracture with 15 cases by Closed Reduction & External Fixation Technique & 15 cases by Open Reduction & Internal Fixation by Plate & screw were done in one unit of department which forms the core of study design. All patients were followed at least 6 months (6-18 months).

PARAMETERS TO BE STUDIED

Radiological fracture union

- **CONSTANT-MURLEY SCORING SYSTEM** for shoulder

The higher the score the higher the quality of the function.

Operative Technique

A. Closed Reduction & External Fixation:-

Patient positioning :- Under general anesthesia the patient is positioned on a special beach chair

RESULTS AND ANALYSIS

For statistical analysis data were entered into a Microsoft excel spreadsheet and then analyzed by SPSS 24.0. and GraphPad Prism version 5. Unpaired proportions were compared by Chi-square test or Fischer's exact test, as appropriate.

It was showed that the table showing the age distribution of the cases that were selected. The mean age group of the cases operated by Closed reduction & external fixation (CREF) was 51.27 with the lowest age being 24 as was decided by our selection criteria and highest being 70. In the Open reduction & internal fixation (ORIF) group the mean age was 43.53 with lowest 19 and highest 65. As we can see the comparison of the age of the cases in both the groups is statistically insignificant (p-value = 0.095) showing that both the groups were similar in their age distribution. Out of 15 cases there were 8 females and 7 males in both the groups. P-value = 1.000 (insignificant) shows that both the groups were similar with regards to sex of the case.

We found out of 15 in CREF group 7 patients had fracture in the left side and 8 patients in the right side whereas 5 had fracture in the left side and 10 in the right side in ORIF group. Insignificant p value (0.456) again shows that the two groups were similar with regards to their side distribution. On the whole among 30 cases 40 % had fractures on the left side and 60 % on the right side. Out of 15 in CREF group 9 patients had fracture due to fall on ground and 6 patients caused by RTA (road traffic accident) whereas 8 had fracture due to fall and 7 had fracture due to RTA in the ORIF group. Insignificant p value (0.7125) again shows that the two groups were similar with regards to their mode of injury. On the whole among 30 cases 56.7 % had fracture due to fall and 43.3 % due to RTA.

It was out of 15 in CREF group 4 patients had single comorbidity (diabetes or hypertension), 3 patients had multiple comorbidity (both diabetes & hypertension) & 8 patients had no comorbidities; whereas 4 patients had single comorbidity and 11 had no comorbidities in the ORIF group. Insignificant p value (0.1761) again shows that the two groups were similar with regards to their comorbidities. On the whole among 30 cases 10% had multiple comorbidities and 26.7% had single comorbidity & 63.3% had no comorbidities. Out of 15 in CREF group 6 patients had 2 part fracture, 7 patients 3 part fractures & 2 patients had 4 part fractures; whereas 5 patients had 2 part fractures, 7 had 3 part fractures & 3 had 4 part fractures in the ORIF group. Insignificant p value (0.8646) again shows that the two groups were similar with regards to their type of fractures. On the whole among 30 cases 36.7% had two part fractures, 46.7% had 3 part fractures & 16.7% had four part fractures.

Our study showed that the mean duration of fracture before surgery was 5.86 days with minimum of 4 days & maximum of 10 days in CREF group. In ORIF group mean fracture duration was 5.33 days with minimum 4 days & maximum 7 days. Both the groups were similar with regards to fracture duration (insignificant p-value 0.3232).

The mean surgery time in CREF group was 47 minutes with minimum 40 minutes & maximum 60 minutes. On the contrary in ORIF group mean surgery time was 88.66 minutes with minimum 60 minutes & maximum 110 minutes. The comparison of surgery time between two groups shows a significant difference between two groups (p value < 0.0001). All the cases were discharged after first pin dressing after 48-72 hrs of surgery with proper advice except for the 2 cases of CREF which had pin tract infection & 2 cases of ORIF which had superficial infection & discharged after complete resolution of infection and stitch removal.

It was out of 15 patients operated by CREF 2 patient develops infection (pin tract infection) which resolved after pin tract dressing & empirical antibiotic & 1 patient had hardware related (k wire loosening) complication & 12 patient developed no complications. But among Open reduction internal fixation group 1 patient developed soft

tissue related problem(soft tissue impingement),2 patient had superficial infection resolved after giving antibiotic as per culture sensitivity report,1 patient developed both suprafacial infection & soft tissue related problem(frozen shoulder),1 patient developed hardware related problem(secondary screw perforation),1 patient varus malunion,1 patient Avascular necrosis(AVN) of head & 1 patient had both varus malunion & AVN & 7 patients developed no complications. We found that in both the groups the patient were followed for a similar duration (insignificant p value 0.5449) with both groups having a mean follow up of around 12-13 months and a maximum & minimum follow up period of around 20 and 6 months respectively . The mean time of union in CREF group was 8.8 weeks with minimum 8 weeks & maximum 10 weeks. On the contrary in ORIF group mean time of union was 12.73 weeks with minimum 10 weeks & maximum 16 weeks. The comparison of surgery time between two groups shows a significant difference between two groups(p value <0.0001) probably due to non disruption of fracture haematoma in case of CREF.

It was showed that the mean CMS in 3 weeks of CREF group was 61.6 with minimum score 50 & maximum 68. On the contrary in ORIF group mean CMS at 3 weeks was 32.8 with minimum 29 & maximum 36. The comparison of CMS between two groups shows a significant difference between two groups(p value<0.0001) . The mean CMS at 6 weeks in CREF group was 69 with minimum score 56 & maximum 80. On the contrary in ORIF group mean CMS at 6 weeks was 59.13 with minimum 50 & maximum 68. The comparison of CMS between two groups shows a significant difference between two groups (p value 0.0002).

Our study showed that the mean CMS at 12 weeks in CREF group was 74.6 with minimum score 60 & maximum 86. On the contrary in ORIF group mean CMS at 12 weeks was 69.6 with minimum 52 & maximum 80. The comparison of CMS between two groups shows no significant difference between two groups(p value 0.0648) . The mean CMS at 24 weeks in CREF group was 79.13 with minimum score 66 & maximum 90. On the contrary in ORIF group mean CMS at 24 weeks was 79.6 with minimum 60 & maximum 94. The comparison of CMS between two groups shows no significant difference between two groups (p value 0.8792). Finally there were 3 excellent (20%), 10 good (66.7%), 2 fair (13.3%) constant murley score grading in CREF group. In ORIF group there were 5 excellent (33.3%), 8 good (53.3%), 1 fair (6.7%) & 1(3.3%) poor constant murley score grading.

DISCUSSION

We conducted this study to evaluate the efficacy of two surgeries – Closed Reduction & External Fixation & Open Reduction & Internal Fixation with Plate Screw fixation technique in the management of Proximal Humerus Fractures in adults.

In our case series we operated on 30 patients ; 15 were operated by Closed Reduction & External Fixation and 15 by Open Reduction & Internal Fixation by Plate Screw fixation.

- We had 16 females out of 30 cases (53.33%). So in our study the average age and the female predominance of the study population is comparable to a study done by Court-Brown CM, Garg A, McQueen MM¹⁰ in 2001.
- In our study on the whole 60% patients (18) were affected on the right side & 40% of patients (12) were affected on left side.
- In our study on the whole 56.7% patients' fracture occurred due to fall which is comparable to the study done by Court Brown CM, Garg A, McQueen MM¹⁰ in 2001.
- Of all the patients 63.3%(n=19) had no comorbidity, 26.7%(n=8) had single comorbidity (diabetes or hypertension), & 10% had multiple comorbidities (both diabetes & hypertension).
- The distribution of Neer type was 36.7%(11) two part fracture 46.7%(14) three part fracture & 16.7%(5) was Four part fractures.
- Mean surgery time in case of closed reduction & external fixation was 47 minutes (Range 40-60 min) & in case of open reduction & internal fixation was 88.67 minutes (Range 60-110 min) with p value of <0.0001 which means the operative time of open reduction is significantly high in compared to closed reduction. The result of Closed Reduction & External Fixation is comparable to a study done by Anil Kumar Gupta, Manu Gupta, Gyanendra Senger¹¹ et al done in 2012 (30-50 minutes). The result of Open reduction & Internal Fixation is comparable to a study done by Michael Leonard, Leibo Mokotedi, Pat Fleming et al¹² done in 2009 (mean operative time 81 min, range 60-123).

- Mean post op hospital stay for closed reduction & external fixation was 3.13 days with minimum 2 days & maximum 8 days while in open reduction & internal fixation it was 3.93 days with minimum 2 days & maximum 10 days.
- Out of 15 patients operated by closed reduction & external fixation 2 patient develops infection (pin tract infection) which resolved after pin tract dressing & empirical antibiotic & 1 patient had hardware related (k wire loosening) complication which is comparable to a study done by Anil Kumar Gupta, Manu Gupta, Gyanendra Senger¹¹ et al in 2012 (out of 16 patients One case of K-wire loosening and one case of pin tract infection were the complications.) infection resolved after giving antibiotic as per culture sensitivity report, 1(6.67%) patient developed both suprafacial infection & soft tissue related problem (frozen shoulder), 1 (6.67%) patient developed secondary screw perforation, 1(6.67%) patient varus malunion, 1(6.67%) patient AVN & 1(6.67%) patient had both varus malunion & AVN. The result is comparable to a study done by Brunner F1, Sommer C, Bahrs C, Heuwinkel R, Hafner C, Rillmann P, Kohut G, Ekelund A, Muller M, Audigé L, Babst R¹³ (2009) et al & Chandan Kumar, Anil Kumar Gupta, Rohit Nath, and Javed Ahmad¹⁴ (2013)
- The mean follow up duration for patients of CREF was 13.33 months while in case of ORIF it was 12.4 months.
- The comparison of fracture union time showed significant difference between two groups (p value <0.0001). The mean fracture union time was higher in the Open reduction & internal fixation group with 12.73 weeks as compared to 8.8 weeks in the closed reduction external fixation group. The result of Closed reduction & external fixation is comparable to the study done by Anil Kumar Gupta, Manu Gupta, Gyanendra Senger¹¹ (2012) et al (mean time of union 6.5+/-1.18 weeks). The result of Open reduction & internal fixation is comparable to the study done by Nitin Sharma¹, Mohit Dhirga, Deepak Sharma et al¹⁵ (2017) (Average union time 12.32 weeks).
- The comparison of CMS score after 3 weeks of surgery showed significant difference between two groups (p value <0.0001). The mean CMS was 61.6 after 3 weeks of Closed reduction & external fixation while it was 32.8 in case of Open reduction & internal fixation.
- The comparison of CMS score after 6 weeks of surgery also showed significant difference between two groups (p value 0.0002). The mean CMS was 69 after 6 weeks of Closed reduction & external fixation while it was 59.13 in case of Open reduction & internal fixation.
- But the comparison of CMS score after 12 weeks of surgery showed no significant difference between two groups (p value 0.0648).
- The comparison of CMS score after 24 weeks of surgery also showed no significant difference between two groups (p value 0.8792).
- The result of Closed reduction & external fixation is comparable to a study done by Anil Kumar Gupta, Manu Gupta, Gyanendra Senger¹¹ (mean constant score after 6 months was 78.1±9.61). The result of Open reduction & Internal fixation is comparable to a study done by Martinez AA, Cuenca J, Herrera A63 (2009) et al (mean Constant score was 80; range, 40-100).
- In case of Closed reduction & external fixation final functional outcome was Excellent 20%(n=3), Good 66.7%(n=10), Fair 13.3%(n=2) which is comparable to a study done by Anil Kumar Gupta, Manu Gupta, Gyanendra Senger¹¹ (2012) et al. In case of Open reduction & internal fixation final outcome was Excellent 33.3%(n=5), Good 53.3%(n=8), Fair 6.7%(n=1), Poor 6.7%(n=1) which is comparable to a study done by Nitin Sharma¹, Mohit Dhirga, Deepak Sharma¹⁵ (2017) et al & Vivek Bansal, H.S Sohal, R.S Bhopari¹⁶ et al (2015).

CONCLUSION

Our study shows that operative time & fracture union time is significantly less in Closed reduction & external fixation. Complications are also less in case of Closed reduction & external fixation in compared to Open reduction & internal fixation. Though the Final CMS score is more or less same in both groups but initially after surgery (upto 6 weeks) CMS score is significantly superior in Closed reduction & external fixation.

Therefore we can say that Closed reduction & External Fixation can also be considered as an effective treatment option for osteosynthesis of judiciously selected proximal humerus fractures in low cost.

Distribution of all parameters in two groups

	CREF	ORIF	P value
Age	Mean 51.27 (70-24)	Mean 43.53 (65-19)	0.0950
Sex	F-8(53.3%), M-7(46.7%)	F-8(53.3%), M-7(46.7%)	1.00
Comorbidity	Multiple-3(2%) Single-4(26.7%) None-8(53.3%)	Multiple-0 Single-4(26.7%) None-11(73.3%)	0.1761
Neer type	2 Part-6(40%), 3part-7(46.7%) 4part-2(13.3%)	2 part-5(33.3%) 3part-7(46.7%) 4part-3(20%)	0.8646
Side	Left-7(46.7%) Right-8(53.3%)	Left-5(33.3%) Right-10(66.7%)	0.4560
Fracture duration	4-10days (mean-5.86)	4-7 days (mean-5.33)	0.3232
Surgery time (minutes)	40-60 min (mean-47 min)	60-110 min (mean-88.67 min)	<0.0001
Time of union (weeks)	8-10 weeks (mean-8.8 weeks)	10-16 weeks (mean-12.73weeks)	<0.0001
CMS (3 weeks)	50-68 (mean-61.6)	29-36 (mean 32.8)	<0.0001
CMS (6 weeks)	56-80 (mean-69)	50-68 (mean-59.13)	0.0002
CMS (12 weeks)	60-86 (mean-74.6)	52-80 (mean-69.6)	0.0648
CMS (24 weeks)	66-90 (mean-79.13)	60-94 (mean-79.6)	0.8792

Distribution of Outcome in two groups

SURGERY TYPE CLOSED/OPEN			
Outcome	CREF	ORIF	TOTAL
Excellent	3	5	8
Row %	37.5	62.5	100.0
Col %	20.0	33.3	26.7
Good	10	8	18
Row %	55.6	44.4	100.0
Col %	66.7	53.3	60.0
Fair	2	1	3
Row %	66.7	33.3	100.0
Col %	13.3	6.7	10.0
Poor	0	1	1
Row %	0.0	100.0	100.0
Col %	0.0	6.7	3.3
TOTAL	15	15	30
Row %	50.0	50.0	100.0
Col %	100.0	100.0	100.0

Chi-square value: 2.0556; p-value: 0.5610

Excellent –CMS score >85,

Good- 71- 85,

Fair -61 - 70,

Poor - <60

Finally there were 3 excellent (20%),10 good (66.7%),2 fair (13.3%) constant murley score grading in CREF group .In ORIF group there were 5 excellent (33.3%),8 good (53.3%),1 fair (6.7%) & 1(3.3%) poor constant murley score grading.

REFERENCES

1. Lee SH,Dargent- Molina P,Breart G 'Risk factors for fractures of the proximal humerus: results from the EPIDOS prospective study' J Bone Miner Res. 2002 May;17(5):817-25.
2. David S. Thyagarajan, Samarth J. Haridas, Denise Jones, Colin Dent, Richard Evans, Rhys Williams 'Functional outcome following proximal humeral interlocking system plating for displaced proximal humeral fractures' Int J Shoulder Surg. 2009 Jul-Sep; 3(3): 57- 62.
3. Obrant KJ,Bungner U,Johul O,Nilsson BE,Sernbo I(1989)Increasing age-adjusted risk of fragility fracture;o significant increasing osteoporosis in successive generations.CalcifTissue Int.44:157-167.
4. Jeremiah Clinton, Amy Franta, Nayak L. Polissar, Blazej Neradilek, Doug Mounce, Howard A. Fink, John T. Schousboe,, and Frederick A. Matsen III et al 'Proximal Humeral Fracture as a Risk Factor for Subsequent Hip Fractures'2009.
5. J. B. Lauritzen , P. Schwarz , P. McNair , B. Lund and I. TransbOl et al 'Radial and Humeral Fractures as Predictors of Subsequent Hip, Radial or Humeral Fractures in Women, and their Seasonal Variation'(1993) 3:133-137.
6. Lind T, Kroner K, Jensen J. The epidemiology of fractures of the proximal humerus. Arch Orthop Trauma Surg. 1989;108(5):285-287.
7. Klaus J Burkhart, Dr. Sven O Diet, Leonard Bastian, Ulrich Thelen, Reinhard Hoffmann, and Lars P Müller 'The Treatment of Proximal Humeral Fracture in Adults' DtschArztebl Int. 2013 Sep; 110(35-36): 591-597.
8. Rockwood and Green's Fractures in Adults 7th ed
9. Felix Brunner, MD, Christoph Sommer, MD,Christian Bahrs, MD, Rainer Heuwinkel,

MD Christian Hafner, MD, Paavo Rillmann, MD,k Georges Kohut, MD,Anders Ekelund, MD, PhD,Mathias Muller, MD, Laurent Audige', DVM, PhD and Reto Babst, MD et al 'Open Reduction and Internal Fixation of Proximal Humerus Fractures Using a Proximal Humeral Locked Plate: A Prospective Multicenter Analysis' Journal of orthopaedic trauma April 2009 DOI: 10.1097/BOT.0b013e3181920e5b Source: PubMed

10. Court-Brown CM,Garg A,McQueen MM(2001) 'The epidemiology of proximal humeral fractures.' 2001 Aug;72(4):365-71.
11. Anil Kumar Gupta, Manu Gupta, Gyanendra Sengar, and Rajendra Nath 'Functional outcome of closed fractures of proximal humerus managed by Joshi's external stabilizing system'Indian J Orthop. 2012 Mar-Apr; 46(2): 216-220.
12. Michael Leonard, Leibo Mokotedi, Uthman Alao, Aaron Glynn, Mark Dolan, and Pat Fleming 'The use of locking plates in proximal humeral fractures: Comparison of outcome by patient age and fracture pattern'Int J Shoulder Surg. 2009 Oct-Dec; 3(4): 85- 89.
13. Brunner F1, Sommer C, Bahrs C, Heuwinkel R, Hafner C, Rillmann P, Kohut G, Ekelund A, Muller M, Audigé L, Babst R 'Open reduction and internal fixation of proximal humerus fractures using a proximal humeral locked plate: a prospective multicenter analysis' J Orthop Trauma. 2009 Mar;23(3):163-72. doi: 10.1097/BOT.0b013e3181920e5b.
14. Chandan Kumar, Anil Kumar Gupta, Rohit Nath, and Javed Ahmad 'Open reduction and locking plate fixation of displaced proximal humerus fractures' Indian J Orthop. 2013 Mar-Apr; 47(2): 156-160.
15. Nitin Sharma , Mohit Dhingra , Deepak Sharma 'Philos Plating in Displaced Surgical Neck of Humerus Fracture' DOI: 10.21276/aimdr.2017.3.3.OR4
16. Vivek Bansal, H.S Sohal, R.S Bhoparai 'Philos Plate in Proximal Humerus Fracture-Its Functional Outcome and Complications' International Journal of Orthopaedics. © 2015 The Authors. Published by ACT Publishing Group Ltd.