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Osteosynthesis of proximal humerus fractures with metaphyseal comminution using dual locking plate

Hyeongsig Bang
(Supervised by professor Sungwook Choi)

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This thesis has been examined and approved.

Chairman Professor : Sungwook Choi _____
Professor : Kyubum Seo _____
Professor : Junyeong Seo _____

Department of Orthopedic Surgery
GRADUATE SCHOOL

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Abstract

Objectives: The purpose of this study is to evaluate the radiological results, clinical results, and complication rates of dual plate fixation for complex type metaphyseal fractures of proximal humerus.

Design: A retrospective, Case series.

Setting: Academic Level Ⅱ Trauma Center.

Patients/Participants: A trauma registry was utilized to identify 96 patients with proximal humerus fractures.

Intervention: Open reduction, internal fixation of complex proximal humerus fractures with a dual plate (N=18).

Main Outcome Measurements: Clinical results of University of California Los

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Angeles(UCLA) score and Constant scores were evaluated. Radiographic results were analyzed based on the duration of union. For evaluation of the degree of anatomical reduction, neck shaft angle (NSA) on the anteroposterior(AP) view of the simple plain radiography was measured using the Paavolainen method, and anterior-posterior angulation(APA) on axial view of plain radiograph or the saggital plane was measured on 3D-CT(3-dimensional computed tomography) images in the preoperative state, and recheck NSA and APA on the radiography in the postoperative state.

Results:

The average UCLA score was 23 points. According to the results of Constant score, 18 patients in case reported average scores of 90.4.

In case, the degree of anatomic reduction measured by the Paavolainen method was good in 14 patients (77.7%), fair in 3 patients (16.6%), and poor in 1 patient (5.6%). Patients in case showed a superior result than past other studies with single plate fixation. In our study, there was 1 case of impingement and 1 case of frozen shoulder, and no other serious complications were encountered

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Conclusions: In patients with comminuted complex proximal humerus fractures, the use of dual locking plate provide stable fixation, preventing to complications such as varus collapse, anterior-posterior angulation, screw cutout, nonunion, malunion, and metal failure. Therefore, dual locking plate technique provide stable fixation and better clinical and radiological results and prevent complication.

Key words: Proximal humerus, Comminuted metaphyseal fractures, Dual plate fixation

Level of Evidence: Therapeutic Level Ⅲ.

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Introduction

Proximal humerus fractures account for approximately 4~5% of all fractures, and approximately 10% of these fractures occur in the age group above 60 years. Proximal humerus fractures account for 45% of all humerus fractures[1-3]. The recently introduced locking plate is clinically more widely used due to its small size, low rigidity, high elasticity, and biomechanical properties such as fixed initial angle and rotational stability. However, in severely comminuted complex type proximal metaphyseal humerus fractures, only using of lateral locking plate does not provide stable fixation, leading to complications such as varus collapse, anterior-posterior angulation, screw cutout, nonunion, malunion, and metal failure. [4-6]. Therefore, a more sturdy and enhanced fixation method, the dual plating technique using the locking compression plate(LCP) plate was developed.

We tried to use the dual plating technique with a proximal humerus locking plate (PHILOS, Synthes, Switzerland) and an additional small plate(Distal radius locking plate-Variable Angle LCP Distal Radius System, Synthes, Switzerland) in 18

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patients with severe comminuted metaphyseal proximal humerus fractures, which were classified according to the Neer classification into grade 3 & 4 or according to the AO-OTA classification into 11-A3.3 & 11-B1.2. We evaluated the clinical and radiological results and complication rates of the dual plate fixation technique. The decision regarding the use of a specific device or a therapeutic approach is based on the surgeon's preference and experience than on the evidence. To the best of our knowledge, this study presents retrospectively collected data of patients after fixation of proximal humerus fractures with a dual locking compression plate.

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Patients and method

Patient selection

After the Institutional Review Board approval, the medical records of 96 patients with proximal humerus fractures between Jan. 2008 and Sept. 2013 were reviewed. 9 patients were lost to follow-up. Of these 9 patients, 2 patients died of unrelated causes before the 6-month follow-up. Inclusion criteria for this study was patients with medial comminution and neck-shaft angulation. The exclusion criteria were patients with neurovascular injury and significant dementia and inability to participate in physical therapy postoperatively.

From Jan. 2008 to Sept. 2013, 87 patients diagnosed with a proximal humerus fracture were selected.

43 of these 87 patients received conservative treatment and 44 patients received surgical treatment with locking compression plates (PHILOS, Synthes, Switzerland). Adult patients who sustained a closed, unstable proximal humerus fracture without neurovascular complication at the time of injury subsequently underwent

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operative management(Table 1).

The average age of the 43 patients who received conservative treatment was 72.3 years (29~90 years); 12 patients (27.9%) were males and 31 patients (72.1%) were females. According to the Neer classification, fractures in 30 patients (69.8%) were classified into 1-part fractures, in 12 patients (27.9%) into 2-part fractures, and in 1 patient (2.3%) into 3-part fractures.

The average age of the 44 patients who received surgical treatment was 69.7 years (48~86 years). Among them, 10 patients were males and 34 patients were females. According to the Neer classification, fractures in 32 patients (72.7%) were classified into 3-part fractures, in 12 patients (27.3%) into 4-part fractures. According to the AO-OTA classification, the fractures were classified as 11-A3.3 (22 patients, 50%), 11-B1.2 (22 patients, 50%).

The causes of the initial fracture in the surgical treatment group were slip (26 patients, 59.1%), road accident (6 patients, 13.6%), and fall (12 patients, 27.2%) (Table 2).

In the surgical treatment group (44 patients), we tried to use dual plating technique using two locking plate in 18 patients who had metaphyseal

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comminuted complex proximal humerus fractures and were classified according to the Neer classification as grade 3 & 4 or the AO classification as 11-A3.3 & 11-B1.2.

We follow up post operative state of patients at 1 month, 2 month, 3month, 6 month, 12 months. We evaluated clinical and radiological result in that moment.

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Surgical technique

The patient is positioned supine on a radiolucent operating room table or placed in the beach chair position. An image intensifier (Pulsera 12" Mobile C-Arm, Philips, Netherlands) is positioned at the head of the bed. Full anesthetic relaxation allows for less traumatic retraction of the deltoid and minimizes dynamic forces on the fracture fragments during reduction.

The deltopectoral approach is used to expose the proximal humerus, as described previously by Badman and Mighell[7]. After delto-pectoral expose, further dissection is made through posterior side of greater tubercle with careful consideration not to injure axillary nerve and posterior circumflex humeral artery which can be identified upon the additional exposure.

The coraco-acromial ligament may be partially or completely released. Similarly, the coraco-humeral ligament is released. The long head of the biceps brachii tendon is identified at its position medial to insertion of the pectoralis major on the humerus. The pectoralis does not typically need to be released. However, if

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left in situ, the long head of the biceps brachii can be a source of pain and we often tenodese it at the time of plate fixation in older patients or those with grossly poor tendon quality[8]. The transverse humeral ligament is released with a knife or electrocautery as the biceps is traced superiorly, and as the tendon courses superiorly, it is used to define the rotator cuff interval. After the rotator interval is released to the base of the coracoid process, the long head of the biceps can be released from the supraglenoid tubercle and superior glenoid labrum if there is a plan for tenodesis.

The proximal humerus locking compression plate(PHILOS, Synthes, Switzerland) is positioned lateral to the bicipital groove and additional locking compression plate(VA-LCP Distal Radius System, Synthes, Switzerland) is positioned posterior to the greater tubercle(Figure.1).

The proximal humerus locking compression plate(PHILOS, Synthes, Switzerland) is initially secured to the humeral shaft with a nonlocked, bicortical screw through the diaphyseal portion of the plate.

Proximal humerus locking compression plate was fixated in order to acquire proper reduction. Then upper arm was rotated internally with 90 degree

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abduction for maximum exposure of posterior aspect of humerus afterwards.

After exposing posterior aspect of hurmerus as described above. Distal radius locking plate (Variable Angle LCP Distal Radius System, Synthes, Switzerland) is secured to the posterior of proximal humeral neck-shaft area with cortical screw through the non-threaded section of the plate, too. Due to the compressive force produced by cortical screw, additional fixation can be achieved by introducing locking screws into variable angle locking screw hole of head portion and fixed angle locking screw hole of body portion after placing distal radius locking plate on posterior contour of proximal humerus.

Locking proximal humerus plate (PHILOS, Synthes, Switzerland) specially designed for both a 3.5 mm general screw and a locking screw was used. Also a distal radius locking plate (VA-LCP Distal Radius System, Synthes, Switzerland), specially designed for both a 2.4 mm general screw and a locking screw was used.

More detailed description of the operative technique can be found in the report by Choi et al[9].

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Postoperative rehabilitation Protocol

Post operatively, an abduction brace was applied for 2 months. 7 days post surgery, passive range of motion exercises for the shoulder were performed using the continuous passive movement machine (ORMED Gmbh, Freiburg, Germany) and performed pendulum exercise. Gradually, active secondary movements using the normal contralateral extremity were started. After 2 months post operatively, patient perform active daily living basically, enhance upper extremities muscle power.

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Clinical evaluation

Ipsilateral shoulder trauma series and, if necessary, using 3D-CT (3-dimensional computed tomography, GIEMENS, SOMOTAM-Sensation), fractures were classified according to the Neer classification & AO-OTA classification[10, 11], After medical records and radiologic examination results were retrospectively analyzed, age group, cause of trauma, associated injuries and complications were evaluated.

Clinical results of University of California Los Angeles(UCLA) score and Constant scores were compared. The UCLA score evaluated the pain, functional range of motion and strength on a 10-point scale, and the patient satisfaction score was assessed on a 5-point scale, thereby obtaining a total possible score of 35 points. Overall, a score of more than 30 points was considered as excellent, a score of more than 23 points was considered as good, a score of 17 points or more was considered as average, and a score of less than 16 points was considered as poor[12]. For evaluating the Constant score, pain score was assessed on a 15-point scale, activity on a 20-point scale, active range of motion on a 30-point scale,

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and strength on a 35-point scale, thereby obtaining a total possible score of 100 points[13].

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Radiological evaluation

Radiographic results were analyzed based on the duration of union. For evaluation of the degree of anatomical reduction, neck shaft angle (NSA) in the anteroposterior (AP) view was measured by using the Paavolainen method[14]. Restoration of the humeral shaft angle of 130 ± 10 degree was considered as good, of 100-120 degree as average, and of 100 degree or less as poor (Figure 2).

To measure the anteroposterior(AP) angle of the humeral head, the angle between the long axis of the humerus and and the humeral head on the preoperative 3D-CT or axial view of simple plain radiography was calculated. Postoperative axial view of simple plain radiography was used to assess the increase in AP angulation (Figure 3).

We checked plain radiographes regular per 1 month postoperatievly, and compared plain radiographes in preoperative and immediately postoperative state and 1 year postoperatively.

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Results

Clinical results

According to the UCLA assessment results, 11 patients reported excellent scores, and 7 patients reported good scores. The average UCLA score, was 28.3 points, according to the Constant score results, 18 patients reported average scores of 59.5.

Radiographic results.

The average bone union time was 11.8 weeks [95% confidence interval (CI), 10.9 weeks–12.9 weeks].

The average preoperative NSA was 89.2 degree and the average immediate postoperative NSA was 121.3 degree. The neck shaft angle (NSA) in Final follow up was 118.7 degree in case.

In our study, the degree of anatomic reduction measured by the Paavolainen method was good in 12 patients (66.6%), fair in 5 patients (27.8%), and poor in 1

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patient (5.6%).

The average preoperative AP (anterior-posterior) angulation was 12.4 degree and the average immediate postoperative AP angulation was 3.4 degree. On the final postoperative f/u X-ray, the average AP angulation was 3.7 degree, and the AP angulation did not increase with time (Table 4).

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Complications

There was 1 case of impingement and 1 case of frozen shoulder, and no other serious complications were encountered.

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Discussion

While treating proximal humerus fractures, many factors need to be considered, such as, the type of fracture, osteoporosis, age, and the accompanying injury; particularly, one should always keep in mind the possibility of contractures due to long-term fixation[15, 16].

In 1970, AO proposed the use of plate and screw fixation for treating proximal humerus fractures, allowing for early mobilization and a good functional recovery. But, Paavolainen suggested that the plate fixed in the superior position can impinge the acromion, and a varus deformity can be the most common problem[14].

The recently developed locking metal plates allow for the insertion of four three-dimensional locking screws, thereby achieving better initial stability and rotational stability resulting in early mobilization[17].

Although the optimal surgical treatment for proximal humerus fractures has not

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yet been determined, many operative techniques have been described, including percutaneous fixation, conventional plate fixation, intramedullary fixation with rods or pins, tension band wiring, and blade plate fixation, locking plate fixation and their clinical outcomes have varied[18].

The current trend for treating severe comminuted or 4-parts proximal humerus fractures is to utilize the endosteal implant, such as fibula shaft allograft, or hemiarthroplasty as its lower profile may reduce malunion, nonunion and varus collapse of neck-shaft portion which are caused by severe comminution.[19, 20]

However, endosteal implant operation and hemiarthroplasty aren't widely performed due to the difficult surgical technique, high cost, limited durability and failure of implant. Though many surgical methods and clinical trials are being conducted in order to complement the demerits which mentioned above, the optimal treatment of severely comminuted or 4-parts proximal humerus fractures still haven't established. Recently, according to the age of patient and degrees of comminution, surgical interventions such as locked plating of the proximal humerus using an endosteal implant or hemiarthroplasty are being carried out. [20, 21]

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There have been several reports about the complications encountered with the locking plate technology. Egol et al. [22] reported complications in 12 of 51 patients (24%) at the 16-month follow-up after locking plate fixation of proximal humerus fractures. Complications occurred in eight patients (16%), including intraarticular screw penetration, osteonecrosis, acute fracture, nonunion, and heterotopic ossification. Similarly, Owsley et al.[23] reported a complication rate of 36% in 53 patients, with intraarticular screw penetration occurring in 23% of patients and a statistically significantly higher rate of radiographic complications was noted in patients older than 60 years of age. In a study by Lee et al.[24], 20% of 45 patients had postoperative complications that included loss of fixation, adhesive capsulitis, and deep infection, while Sudkamp et al.[25] reported various complications in 34% of 155 patients including screw penetration, plate impingement, infection, loss of reduction with or without screw perforation, humeral head osteonecrosis, nonunion, screw loosening, plate pullout, and implant breakage. Brunner et al. [26] reported an overall complication rate of 35% and Badman et al. [18] reported 13 cases with complications (16%) among 81 patients; varus collapse in 5 patients (6%), intraarticular screw penetration in 3

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patients (3.7%), and osteonecrosis in 5 patients (6.2%). Königshausen et al.[27] reported 12 (23.1%) cases with complications among 73 patients. The overall complication rate in the current study was not higher compared to that in previous reports (22% versus 16-36%)

Our study demonstrated that severe metaphyseal comminuted complex proximal humerus fractures caused by high energy trauma, which were classified according to the Neer Classification as types 3 & 4 and also AO classification as 11-A3.3 or 11-B2.3, were treated with single plate fixation can lead to complications such as nonunion, malunion, fixation failure and metal failure.

Complications can be of two types, 1) technical complications in plate positioning, length of the screws or secondary screw cutout strongly influence the final clinical result; and 2) specific complications related to this technology such as pseudarthrosis or plate fixation failure.[28]

In our study, 11 (45.8%) complications related to an incorrect surgical technique were encountered in 28 cases (single plate group) at the end of the operative procedure: fixation failure was noted in three cases; infection, impingement, and frozen shoulder in two cases each; and nonunion and malunion in one case each.

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Also there was one (4.1%) complication related to incorrect technology, and metal failure was observed (plate breakage) (Figure 4).

We tried to prevent these complications, such as progression of postoperative varus deformity or increase in the anterior-posterior angulation. Hence according to the concept of an additional plate, we fixed a VA-LCP distal radius plate on the posterior aspect of the proximal humerus as a dual plate fixation technique, which was attempted for the first time.[9] (Figure 5). VA-LCP distal radius plate functions not only as bridge plate to prevent nonunion and varus collapse of neck-shaft portion which are caused by severe comminution but also as buttress plate to prevent anterior-posterior angulation of humeral head. Among many other small plates which do not cause neuro-vascular injury and can easily be anchored with small additional surgical field exposure, yet screw jamming-free with screws from PHILOS plate, VA-LCP anatomically contoured volar distal radius plate was applied for its best mergence with posterior contour of proximal humerus.

There are some advantages in using dual plate technique. First, dual plate technique can acquired firmer internal fixation than single plate technique.

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Secondly, surgical technique is much simpler compared to fibula allograft using endosteal implanting operation. Lastly, on comparison with hemiarthroplasty, dual plate technique uses autologous bone instead of metal implants which leads to decrease of operation fee. When it comes to drawbacks of dual plating technique, Neurovascular or soft tissue injury can occur during surgical intervention, for dual plating technique requires vast surgical field exposure.

In the dual plate group, there were two (14.2%) cases with complications related to initial incorrect surgical technique in 18 cases at the end of the operative procedure: impingement was noted in one case and frozen shoulder in one case.

Though, the database of this research is limited to few cases, dual plate technique can be another optimal surgical treatment in metaphyseal commminuted complex proximal humerus fracture.

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Conclusion

In patients with comminuted complex proximal humerus fractures, the use of dual locking plate provide stable fixation, preventing to complications such as varus collapse, anterior-posterior angulation, screw cutout, nonunion, malunion, and metal failure, instead of using hemiarthroplasty.

Dual plate fixation for humerus fractures allowed for early mobilization due to the solid initial fixation. This technique can be considered to be a valuable method for the treatment of proximal humerus fractures, and patients who underwent this technique showed relatively better clinical and radiological results compared to patients who did not receive surgery. In patients with comminuted complex proximal humerus fractures, Varus deformity or AP angulation can occur as a complication after single plate fixation, and therefore dual plate fixation can provide better clinical and radiological results.

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References

1. Dimai HP, Svedbom A, Fahrleitner-Pammer A, Pieber T, Resch H, Zwettler E, et al. Epidemiology of proximal humeral fractures in Austria between 1989 and 2008. *Osteoporos Int*. 2013.

2. Huttunen TT, Launonen AP, Pihlajamäki H, Kannus P, Mattila VM. Trends in the surgical treatment of proximal humeral fractures - a nationwide 23-year study in Finland. *BMC Musculoskelet Disord*. 2012;13:261.

3. Bell JE, Leung BC, Spratt KF, Koval KJ, Weinstein JD, Goodman DC, et al. Trends and variation in incidence, surgical treatment, and repeat surgery of proximal humeral fractures in the elderly. *J Bone Joint Surg Am*. 2011;93:121-131.

4. 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;22:542-549.

5. Jung WB, Moon ES, Kim SK, Kovacevic D, Kim MS. Does medial support decrease major complications of unstable proximal humerus fractures treated

제주대학교 중앙도서관
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with locking plate? *BMC Musculoskelet Disord*. 2013;14:102.

6. Matejcić A, Vidović D, Ivica M, Durdević D, Tomljenović M, Bekavac-Beslin M, et al. Internal fixation with locking plate of 3- and 4-part proximal humeral fractures in elderly patients: complications and functional outcome. *Acta Clin Croat*. 2013;52:17-22.

7. Badman BL, Mighell M. Fixed-angle locked plating of two-, three-, and four-part proximal humerus fractures. *J Am Acad Orthop Surg*. 2008;16:294-302.

8. Namdari S, Lipman AJ, Ricchetti ET, Tjoumakaris FP, Huffman GR, Mehta S. Fixation strategies to prevent screw cut-out and malreduction in proximal humeral fracture fixation. *Clin Orthop Surg*. 2012;4:321-324.

9. Choi S, Kang H, Bang H. Technical tips: Dualplate fixation technique for comminuted proximal humerus fractures. *Injury*. 2014.

10. Neer CS. Displaced proximal humeral fractures. I. Classification and evaluation. *J Bone Joint Surg Am*. 1970;52:1077-1089.

11. TP R, WM M. AO Principles of Fracture Management. New York, NY: AO Publishing; 2000. p. 281–289.

12. Amstutz HC, Sew Hoy AL, Clarke IC. UCLA anatomic total shoulder

제주대학교 중앙도서관
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arthroplasty. *Clin Orthop Relat Res*. 1981:7-20.

13. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res*. 1987:160-164.

14. Paavolainen P, Björkenheim JM, Slätis P, Paukku P. Operative treatment of severe proximal humeral fractures. *Acta Orthop Scand*. 1983;54:374-379.

15. Wijgman AJ, Roolker W, Patt TW, Raaymakers EL, Marti RK. Open reduction and internal fixation of three and four-part fractures of the proximal part of the humerus. *J Bone Joint Surg Am*. 2002;84-A:1919-1925.

16. Lill H, Hepp P, Korner J, Kassi JP, Verheyden AP, 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*. 2003;123:74-81.

17. Fankhauser F, Boldin C, Schippinger G, Haunschmid C, Szyszkowitz R. A new locking plate for unstable fractures of the proximal humerus. *Clin Orthop Relat Res*. 2005:176-181.

18. Badman B, Frankle M, Keating C, Henderson L, Brooks J, Mighell M. Results of proximal humeral locked plating with supplemental suture fixation of rotator cuff.

제주대학교 중앙도서관
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J Shoulder Elbow Surg. 2011;20:616-624.

19. 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.

20. Cai M, Tao K, Yang C, Li S. Internal fixation versus shoulder hemiarthroplasty for displaced 4-part proximal humeral fractures in elderly patients. *Orthopedics*. 2012;35:e1340-1346.

21. Hettrich CM, Neviaser A, Beamer BS, Paul O, Helfet DL, Lorich DG. Locked plating of the proximal humerus using an endosteal implant. *J Orthop Trauma*. 2012;26:212-215.

22. Egol KA, Ong CC, Walsh M, Jazrawi LM, Tejwani NC, Zuckerman JD. Early complications in proximal humerus fractures (OTA Types 11) treated with locked plates. *J Orthop Trauma*. 2008;22:159-164.

23. Owsley KC, Gorczyca JT. Fracture displacement and screw cutout after open reduction and locked plate fixation of proximal humeral fractures [corrected]. *J Bone Joint Surg Am*. 2008;90:233-240.

24. Lee CW, Shin SJ. Prognostic factors for unstable proximal humeral fractures

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treated with locking-plate fixation. *J Shoulder Elbow Surg*. 2009;18:83-88.

25. Südkamp N, Bayer J, Hepp P, Voigt C, Oestern H, Kääb M, et al. Open reduction and internal fixation of proximal humeral fractures with use of the locking proximal humerus plate. Results of a prospective, multicenter, observational study. *J Bone Joint Surg Am*. 2009;91:1320-1328.

26. 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;23:163-172.

27. Königshausen M, Kübler 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 fractures. A reliable system? *Injury*. 2012;43:223-231.

28. 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;19:489-494.

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Table 1. Patient selection flowchart

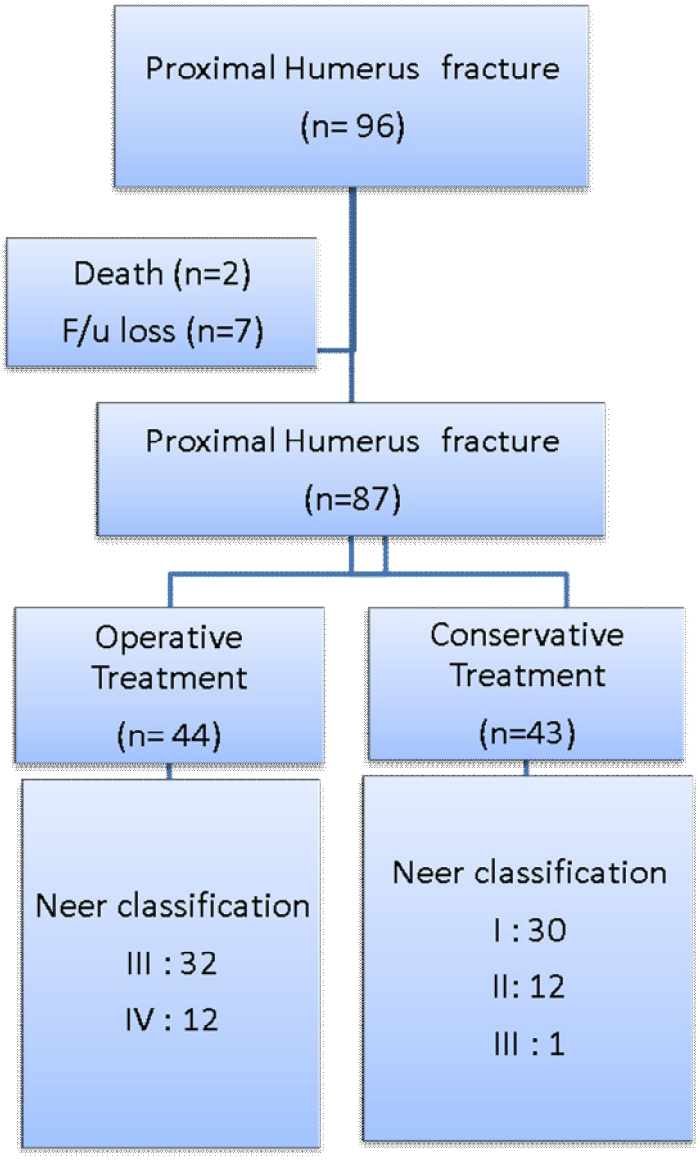

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Table 2. Patient dermographiccharacrteristics

		Dual plate Group
N		18
Sex	Females	12
	Males	6
Follow up period(mean) : month		12~38(25.1)
Neer classification	Ⅲ(%)	13 (72.2)
	Ⅳ(%)	5 (27.8)
AO-OTA classfication	11-A3.3(%)	7 (38.9)
	11-B1.2(%)	11 (61.1)
Mechanism of injury	Slip (%)	12 (66.6)
	Fall (%)	4 (22.2)
	Road accident(%)	2 (11.1)

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Table 3. Clinical results

		Dual plate Group
UCLA score	Excellent(%)	11(61.1)
	Good(%)	7(38.9)
	Bad(%)	0
	Average	23
Constant score	Average	59.5
Total N		18

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Table 4.Radiological results

		Dual plate Group
Averagebone union time (weeks)		11.8
Average Neck shaft angle (angle, °)	Preoperative	89.2
	Immediate postoperative	121.3
	Final follow up	118.7
Paavolainen	Good(%)	12(66.6)
	Fair(%)	5(27.8)
	Poor(%)	1(5.6)
Average AP angulation (angle, °)	Pre-operative	12.4
	Immediate postoperative	3.4
	Final follow up	3.7
Total N		18

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Figure 1.

Dual plate technique with a locking compression plate on the proximal humerus lateral side and additional distal radius locking plate on the posterior aspect of humerus.

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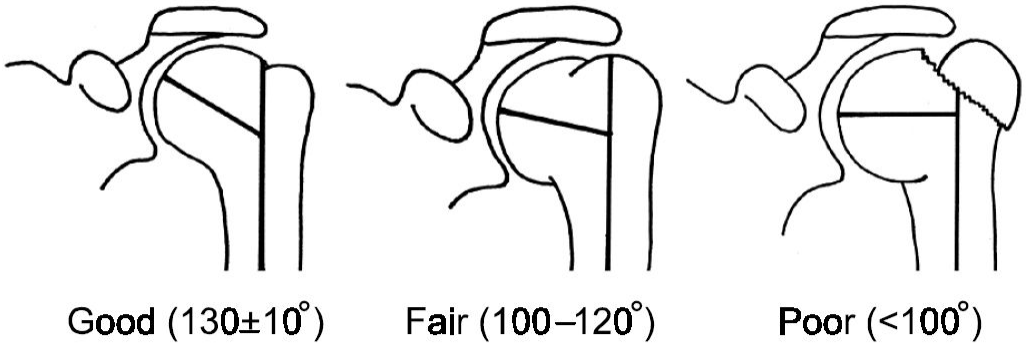

Figure 2.

Radiological evaluation according to the Paavolainen method

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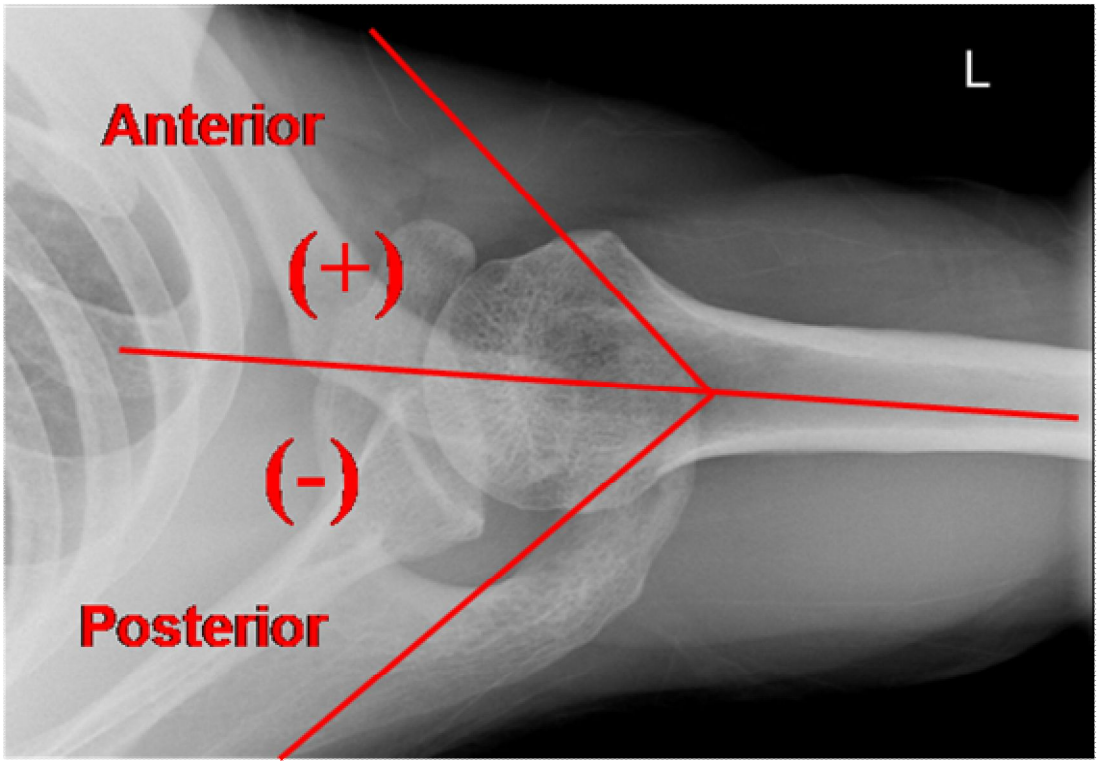

Figure 3.

Radiological evaluation of Anterior-posterior angulation(APA) using the axial view plain radiograph

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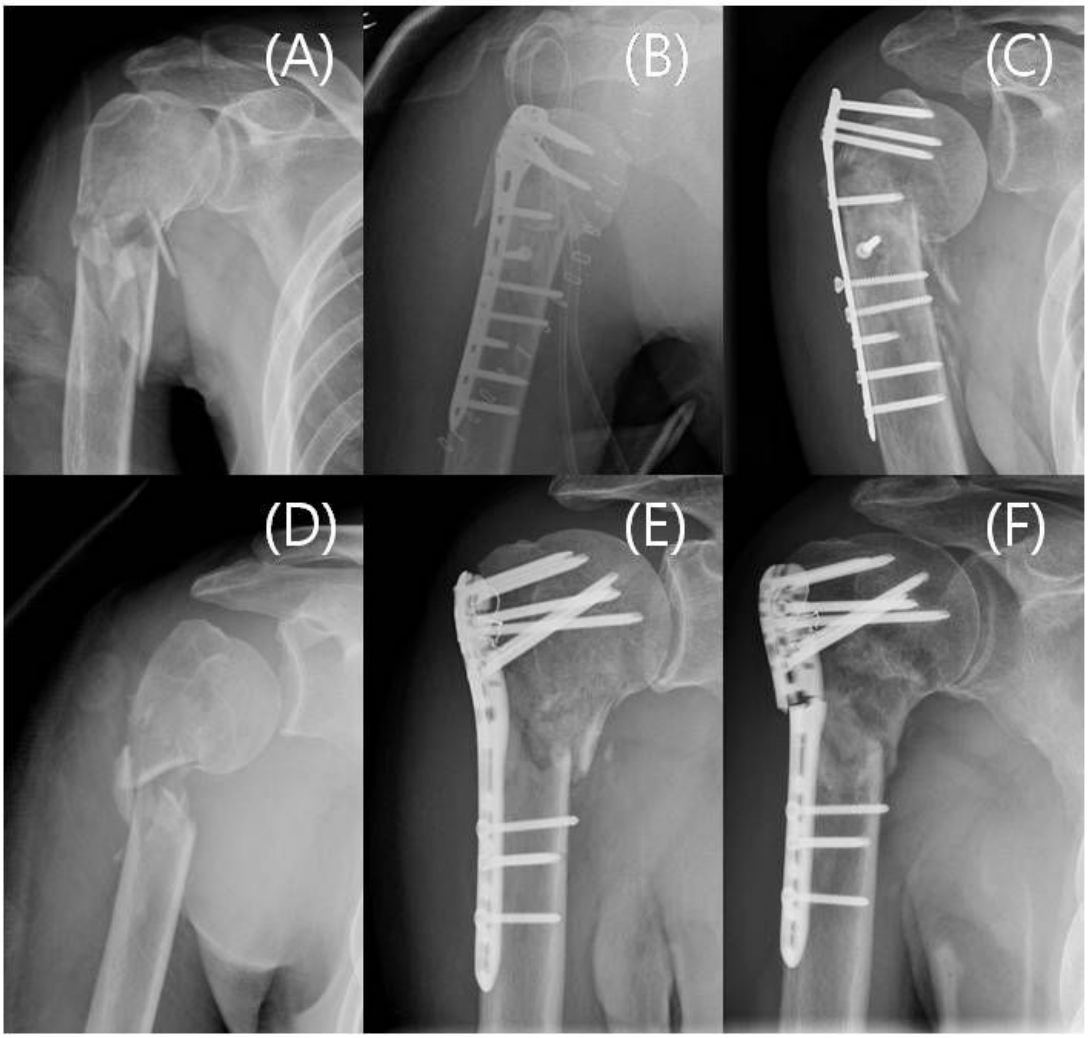

Figure 4.

(A) A 54-year-old male patient sustained a three-part proximal humerus fracture with metaphyseal communition in a road accident. (B) A postoperative radiograph showed nonanatomic reduction and lateral bone beak and short locking screws which did not reach the subchondral bone. (C) Plate and screw pullout from the head and a varus angulation deformity at the fracture site at

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four months after the operation

(D) A 56-year-old male patient sustained a two-part proximal humerus fracture with communition severely due to a slip during a seizure attack.(E) Postoperative radiograph showed a medial metaphyseal bone defect and displaced medial bone fragment. (F) Plate breakage at the fracture site occurred at 15 months postoperatively during physical therapy.

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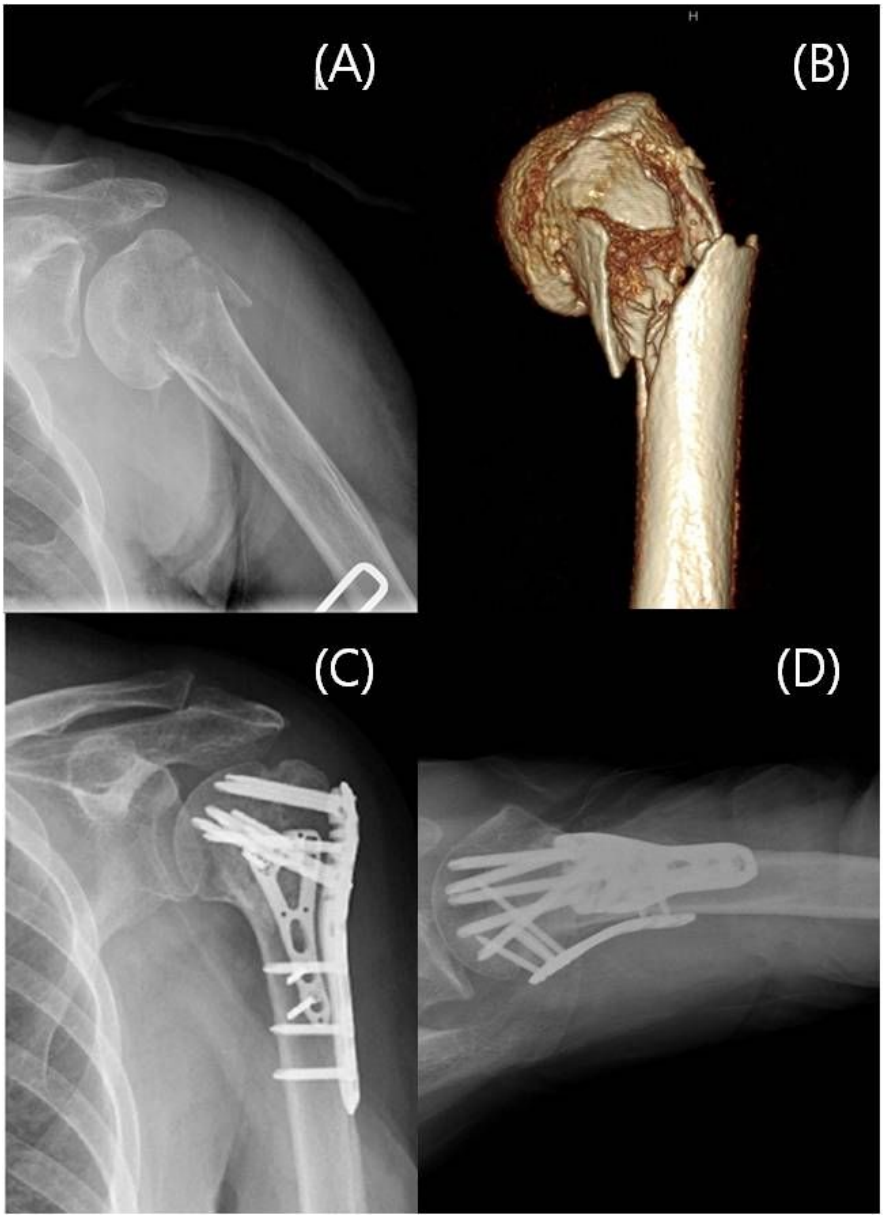

Figure 5.

(A,B) A 74-year-old male sustained a three-part comminuted fracture of the left proximal humerus due to a fall. (C,D) Postoperative radiograph showed anatomic reduction and a small varus angulation with the use of the proximal humerus

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locking plate and the distal radius locking plate in the AP and axial view.

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