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Second generation locked plating for complex proximal humerus fractures in very elderly patients

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ABSTRACT

Objectives: Humeral head sacrificing procedures are more favored in elderly patients with complex proximal humerus fractures because of high incidence of failures and complications with osteosynthesis. The purpose of this study is to assess the outcome of second generation locked plating techniques in 3 and 4 part fractures in active elderly patients >70 years with an emphasis on function and complications.
Materials and methods: 29 patients with displaced 3 and 4 part proximal humerus fractures were treated using the principles of second-generation proximal humerus locked plating. Fixed angle locked plating (PHILOS) using the anterolateral deltoid spilt approach augmented with traction cuff sutures was performed. Minimum of 7 locking head screws including 2 calcar screws were used. In cases with a comminuted medial calcar, an endosteal fibular strut was used. Subchondral metaphyseal bone voids were filled with injectable calcium phosphate cement. Radiological outcome (union, head – shaft angle, tuberosity reduction), functional outcome assessment (Constant and ASES scores) and complications (loss of reduction, nonunion and osteonecrosis) were assessed.
Results: The fracture united in 24 of the 26 patients available for follow up at a mean of 27 months (12–40 months). 3 patients developed complications that required arthroplasty (fixation failure in 2 patients and osteonecrosis in 1 patient). Follow up age adjusted Constant (63.1 ± 11.9) and ASES scores (62.58 ± 7.5) showed the extent of functional improvement post surgery. Patients with fractures having a non-comminuted medial calcar and valgus displacement of the humeral head had better functional scores and fewer complications.
Conclusion: Osteosynthesis with second generation locked plating techniques provide satisfactory outcome in very elderly patients with complex proximal humerus fractures with minimal complications.

Introduction

Proximal humerus fractures have a bimodal distribution. The fractures in the elderly are usually osteoporotic low velocity fractures. Majority of these osteoporotic fractures can be treated conservatively with emphasis on early mobilization [1]. Complex fractures with displaced tuberosities, impacted articular segments and fracture dislocations will benefit from surgical management even in elderly patients [2]. While arthroplasty is a good treatment option in elderly patients with complex fractures, osteosynthesis have been reported with poor results and a higher reoperation rate [3]. Locked plating has been reported to achieve reproducibly good results in younger patients with complex fractures but the results

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have been variable in elderly patients. The technique of proximal humerus locked plating has undergone significant progress over the last decade. Second generation locked plating principles for proximal humerus fractures [4] advocate the use of anterolateral deltoid split approach, stress the importance of medial column support, avoiding varus reduction, use of traction cuff sutures and endosteal support in cases with a non-supportive medial column (Fig. 1). These techniques may help overcome the problems of osteoporosis, chances of humeral head osteonecrosis with the deltopectoral approach and presence of medial comminution, that commonly complicate outcome after locked plating in elderly patients. The purpose of this prospective study is to analyse the outcome of second generation locked plating techniques in complex proximal humerus fractures in patients >70 years of age.

Patients and methods

Records of 29 elderly patients operated for a displaced 3 and 4 part proximal humerus fractures with locked plating between 2012 (Feb) – 2014 (Nov) were prospectively collected and assessed. Our institutional review board approved the study and informed consent was obtained from all patients. Patients >70 years leading an active lifestyle with unrestricted use of the injured shoulder and limb were included. Pathological fractures, homebound patients, patients with previous history of rotator cuff problems, anatomical neck fractures, head splitting fractures and fracture dislocations were excluded. Preoperatively, patients were evaluated with an AP view of the injured shoulder and a CT scan as part of the hospital's protocol.

Surgical technique

A single surgeon through an anterolateral deltoid split operated all patients. Four non-absorbable sutures (no. 2 fiberwire: Arthrex – India) were placed in the cuff – tuberosity junction to help reduction of the head and tuberosity fragments. After securing the tuberosities, the articular fragment was gently manipulated using Schantz pins as joysticks or disimpacted with blunt elevators. The reduced head fragment was fixed provisionally using 1.8 mm K wires to the shaft followed by reduction of the tuberosities. The reduced tuberosity fragments were secured to each other using a fiberwire suture going around the tuberosities. A standard construct with a minimum of 7 locking head screws was used to fix the proximal segment including 2 kickstand screws in the PHILOS (Synthes – India). Remaining three rotator cuff sutures were secured to the plate holes after completing fixation.

In varus-displaced fractures with a comminuted medial column, an autologous fibular graft was used as an endosteal strut for stabilization of the osteoporotic humeral head. Metaphyseal bone voids if present after reduction were filled with injectable calcium phosphate in cases with a supportive medial column to provide subchondral support to the humeral head and maintain the head tuberosity relationship.

Technique of fibular graft harvest and usage

A 6–9 cm mid-segment autograft fibula was harvested from the ipsilateral lower limb. The graft was beveled on one side. The graft was introduced into the humeral canal through the lateral fracture lines with the beveled side facing proximal. The graft was pushed to the medial side of the shaft and then levered up using a 2.5 mm K wire joystick to prop up the humeral head and reconstruct the medial column. The reduced humeral head position was then provisionally secured by fixing the graft to the humeral shaft using 2 K wires. The screws from the plate help secure the graft in its final position (Fig. 2).

Passive range of motion exercises was started from day 1. A graduated supervised home physiotherapy was instituted for a period of 6 weeks followed by strengthening exercises. Patients were seen at the outpatient clinic every 3 weeks till union then at 6 and 12 months and at the final follow up.

Follow up assessment

Immediate postoperative and final follow up radiographs were assessed to measure head shaft angle, loss of head height (as described by Hettrich et al. [5]), tuberosity reduction (unsatisfactory if >5 mm initial displacement in any plane, and further loss of reduction in millimeters was recorded), loss of reduction and fixation, avascular necrosis and appearance of degenerative

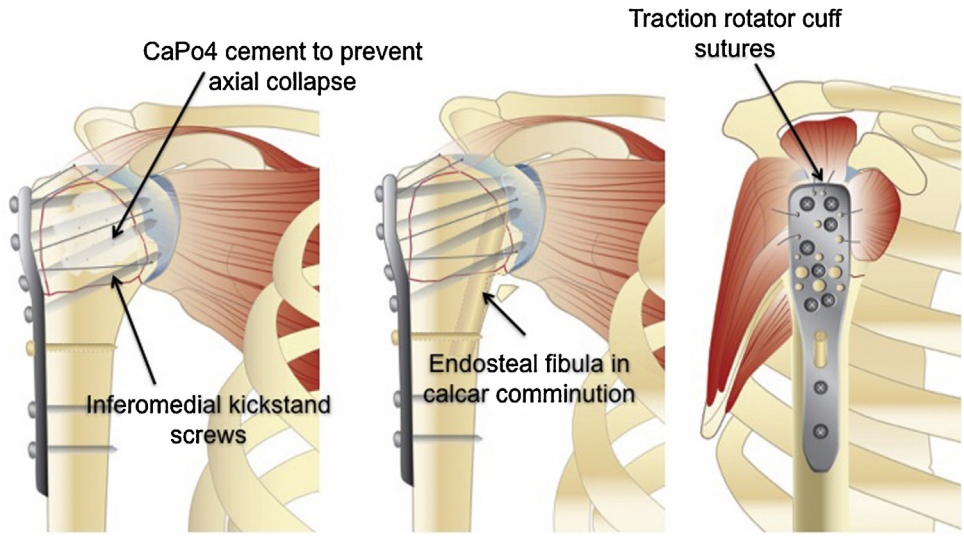

Fig. 1. Summary of surgical techniques used in second generation locked plating of proximal humerus fractures.

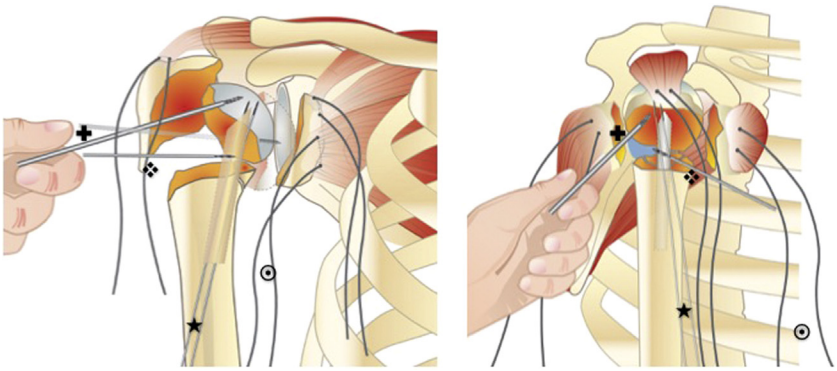

Fig. 2. Technique of using endosteal fibula: Once the traction cuff sutures (⊙) are placed, the head fragment is brought out of varus using a Schantz pin (+). The beveled fibular graft is inserted into the medullary cavity through the lateral fracture line and retrogradely guided into position using a threaded K wire (❖) and held in place using two K wires into the humeral head (★).

arthritis. Functional assessment was done using the Constant score adjusted for age and gender [6] and the American shoulder and elbow society score (ASES) at last follow up.

Statistical analysis

Internal subgroup analysis was performed using *T* tests to compare outcome scores (age adjusted Constant scores and ASES scores) and Chi square test to compare the incidence of complications with respect to humeral head displacement (varus/valgus) and status of the medial column (presence or absence of comminution). A 'P' value of < 0.05 was considered the level of significance.

Results

The mean age was 79 ± 7 years. The mean follow up was 27 ± 9 months. 3 patients were lost in follow up, 2 patients died due to unrelated causes and 1 patient was not traceable. Of 26 patients at final follow up, 15 were females and 11 males. There were 11 (3) part fractures and 15 (4) part fractures. 12 fractures were impacted in valgus and 14 fractures were displaced into varus. 16 patients had a non-comminuted medial column and 10 patients had medial column comminution in which an endosteal fibular graft was used. Calcium phosphate void fillers to provide subchondral support were required in 7 patients. 3/26 patients (11%) underwent arthroplasty due to complications following osteosynthesis and were excluded from final radiographic and functional assessment.

24 (92%) of the 26 fractures united at follow up (Fig. 3). The mean head shaft angle was $132^\circ \pm 4^\circ$ postoperatively and $129^\circ \pm 5^\circ$ at follow up, the change was not significant ($P = 0.7$). Tuberosity reduction was found satisfactory in all patients. The mean loss of head height was $1.3\,mm \pm 0.6\,mm$. Varus displacement of the head ($< 10^\circ$) was seen in 3 patients but ultimately went on to unite without intervention.

The mean active elevation was $111^\circ \pm 14^\circ$. The mean active external rotation was $34^\circ \pm 7^\circ$ and the mean active internal

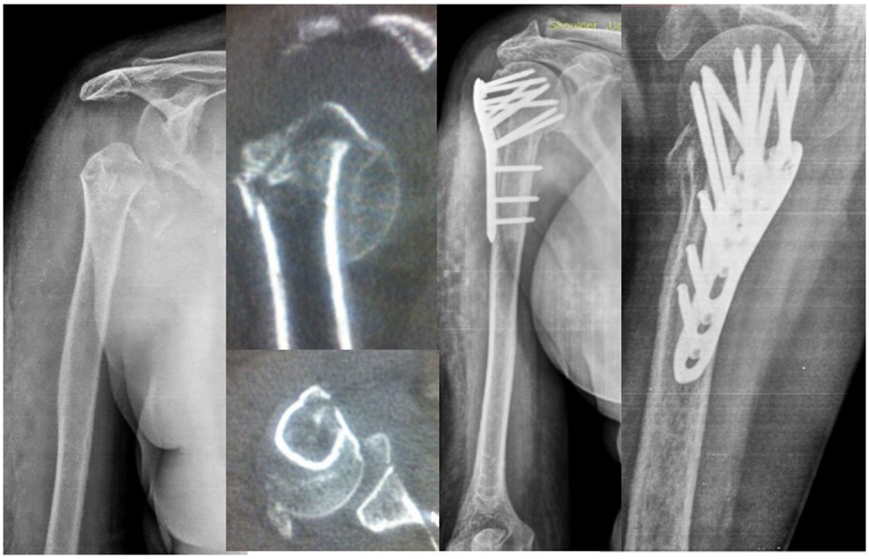

Fig. 3. Varus 4 part osteoporotic fracture in 81 years old male treated using II generation locked plating principles shows an excellent radiological outcome 1-year post surgery.

Table 1
Functional outcome and complications: statistical analysis.

Functional score	Valgus impacted	Varus displacement	P Value
Constant	70.4 ± 8.4	56.3 ± 9.65	**0.02**
ASES	67.07 ± 6.01	57.8 ± 6.05	**0.02**
Major complications	0/12	3/14	0.09
	No medial comminution	Medial comminution	
Constant	67.6 ± 10.3	57.05 ± 8.5	**0.04**
ASES	64.07 ± 7.47	60.2 ± 6.6	0.2
Major complications	1/10	2/16	0.21

Bold values indicate a measure of statistical significance.

rotation was L1. The mean age – gender adjusted Constant score and the ASES score was 63.1 ± 11.9 and 62.58 ± 7.5 respectively. Valgus displaced fractures performed functionally better compared to varus-displaced fractures. Fractures with a non-comminuted medial column had better function according to the Constant score but no difference was noted in the ASES score. The number of complications was higher in varus-displaced fractures and in cases with a comminuted medial column, but the difference was not statistically significant. Results of statistical analyses are summarized in Table 1.

Major complications requiring surgical intervention were seen in 3 patients (11.5%). 2 patients experienced loss of fixation with varus collapse (>20°) of the articular fragment and secondary intra-articular screw penetration (Fig. 4). Humeral head osteonecrosis was seen in 1 patient (4%). Patients with loss of fixation were treated with a reverse shoulder arthroplasty and 1 patient with osteonecrosis was treated with hemiarthroplasty. No evidence of degenerative arthritis was seen.

Discussion

The technique of proximal humerus locked plating has improved over the last decade with the advancement of trans-deltoid surgical approach, suture fixation and biological augmentation to resist failures. Our purpose was to study the effectiveness of second-generation proximal humerus locked plating techniques in elderly patients who are often osteoporotic.

Major observations from our results include (i) satisfactory results with second generation techniques in 3 and 4 part fractures in very elderly patients, (ii) use of endosteal fibula and injectable substitutes help minimise varus and axial collapse and maintains head-tuberosity relationship, (iii) minimal rates of humeral head osteonecrosis with the deltoid split approach and (iv) higher rate of failures in patients with varus displacements and comminuted medial column. These findings suggest a low rate of complications and better results compared to published results of first generation locked plating [7] (Table 2).

Few studies have shown good results with ORIF by locked plates in elderly patients with 3 and 4 part fractures [5] but most of the studies reported so far had an average age of around 60 years [8,9] compared to 79 years in the current study. Barlow et al. [10], reported good outcome with locked plating in a group of 22 patients aged more than 75 years, but 11/22 cases in their series were Neer 2 part fractures.

Solberg et al. [2] reported complications of avascular necrosis, humeral head perforation, loss of fixation and varus collapse in 19 of 24 (79%) patients with varus-displaced fractures in their study group with a mean age of 65 years. Incidence of same complications was much lesser in our patients 6 of 14 (42%) with varus-displaced fractures showing the efficacy of the technique.

The second-generation concepts in proximal humerus locked plating advocate the use of anterolateral deltoid split approach to avoid possible interference with humeral head blood supply [11], use of rotator cuff sutures, emphasize on medial column stabilization [12] and use of endosteal supports. These concepts formed the basis for our study.

The status of medial column and its restoration play a key role in successful results following locked plate fixation [13]. Infero-medial kickstand screws have been shown to be extremely important in preventing varus collapse. In osteoporotic fractures, both axial and varus collapse can occur despite an angle stable

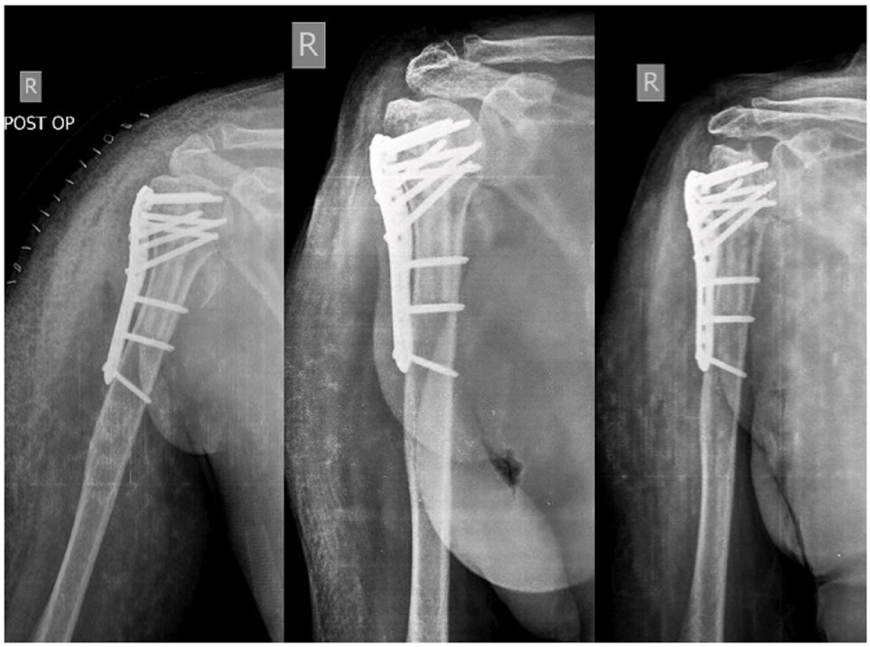

Fig. 4. A varus 4 part fracture in a 77 years female treated with an endosteal fibula to address calcar comminution. Initial x ray shows a good reduction and head shaft relationship. Follow up X rays at 3 and 6 months shows progressive collapse and failure.

Table 2
Comparison of complications with first generation locked plating techniques.

Study	Mean age	Total fractures/type	Complications	Osteonecrosis	Varus collapse	Reoperation
Sproul et al. [7][a]	62 ± 4	514/2,3 and 4 part	48.8%	10.8%	16.3%	13.8%
Current study (2016)	79 ± 7	26/3 and 4 part	11.5%	3.8%	7.7%	11.5%

[a] Systematic review of first generation locked plating techniques.

construct [14], which might be minimised by using juxta-articular support with injectable substitutes or a strut graft respectively.

Both techniques have been described to be effective in providing endosteal support [15,16]. The use of an endosteal fibula is described to augment the strength of fixation in cases with comminuted medial cortex [17–19]. Juxta-articular support with injectable osteo-conductive bone forming cement helps healing, prevents axial settling of the humeral head and maintains the relationship between the head and the tuberosities. It can be used to fill metaphyseal voids if the medial column is supportive. Recent data [20,21] also suggests that use of an endosteal graft, rotator cuff sutures, bone void fillers, using kickstand and divergent head screws constitute important intra-operative techniques to minimise postoperative complications.

The limitations of the study include a small sample size and lack of a control group, so the interpretation of data is subject to bias. Use of an autograft fibula can also add to donor site morbidity. We used an autograft fibula since we did not have access to allografts. The strengths include prospective collection of all data, blinded analysis of results and inclusion of homogenous fracture patterns in a select cohort of patients.

Second generation locked plating concepts achieves excellent short term radiographic and functional results in complex 3 and 4 part fractures with valgus displacement and a non-comminuted medial column. Varus displacement and a comminuted medial column are associated with a higher incidence of loss of fracture reduction and inferior shoulder function but the results are better compared to previously published reports. Our study provides a standardized protocol to follow when performing locked plating of complex 3 and 4 part fractures in very elderly patients. However, control based multi-center randomized control trials are required in future to validate and establish the efficacy, reproducibility and potential advantages of the technique over conventional locked plating and arthroplasty

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None.

Conflict of interest

Authors declare no conflict of interest; no financial biases and no external funding were received. The institutional review board (Parvathy hospital) approved the study.

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