Section: Orthopedics

Original Research Article

A PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME IN DISPLACED PROXIMAL HUMERUS FRACTURES TREATED WITH PROXIMAL HUMERUS LOCKING PLATE

P. Surya Teja[1], B. Chandra Shekar[2], R G. Madhu[3]

[1,2]Assistant Professor, Department of Orthopedics, Rangaraya Medical College, Kakinada, Andhra Pradesh, India.
[3]Associate Professor, Department of Orthopedics, Rangaraya Medical College, Kakinada, Andhra Pradesh, India.

Received *: 04/05/2024*
Received in revised form *: 25/06/2024*
Accepted *: 10/07/2024*

Corresponding Author:
Dr. R.G. Madhu,
Associate Professor, Department of Orthopedics, Rangaraya Medical College, Kakinada, Andhra Pradesh, India.
Email: revulagadda@yahoo.com

DOI: 10.70034/ijmedph.2024.3.23

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2024; 14 (3); 129-136

ABSTRACT

Background: To assess the functional outcome of PHILOS (proximal humerus internal locking system) plating in proximal humerus fractures.

Materials and Methods: Twenty-five displaced fractures of proximal humerus (in twenty-five patients) treated with PHILOS(proximal humerus locking system) plate between MAY 2021 and APRIAL 2023. The study was conducted in department of Orthopedics & Traumatology Government General hospital, Rangaraya Medial College Kakinada, Andhra Pradesh, India. Patients between 18 to 49 yrs age with proximal humerus fractures.

Results: The present study was done to evaluate functional out come and complication following surgical management of proximal humerus fracture by locking compression plate. (PHILOS PLATE). In PHILOS (proximal humerus internal locking system system) system of the threaded heads of the screws in the plate itself provides for a construct with angular and axial stability, eliminating the possibility of screw toggling or sliding of the screws in the plate holes. Coupled with a divergent or convergent screw orientation to head of humerus provide improved resistance to pull out and failure of fixation. Also, whereas conventional plating systems depend on compression between the plate undersurface and bone for stability, this is not the case for the locking plates. This lessens the chance of stripping the thread in osteoporotic bone, as the plate/bone interface is not loaded along the screw axis. This also allows for a more biological fixation as the underlying periosteum and blood supply to the fractured regions are much less compressed.

Conclusion: In conclusion proximal humerus internal locking system (PHILOS) is mechanically and biologically an advantageous implant in proximal humeral fractures particularly in comminuted fractures and in osteoporotic bones in elderly patients, thus allowing early mobilization.

Keywords: PHILOS, Humerus Fracture, Biological Fixation, Conventional Plating system.

INTRODUCTION

Proximal humerus fractures are one of the commonest fractures occurring in the skeleton. They account for approximately 4 – 5% of the all fracture,[1,2]PProximal humeral fractures are the second most common upper- extremity fracture and the third most common fracture, after hip fractures and distal radial fractures, in patients who are older than sixty-five years of age.[3]

Proximal humerus fractures are common and have a bimodal age distribution. Fracture-dislocations in younger patients result from high energy trauma and most surgeons attempt open reduction and internal fixation, if at all possible. Osteoporotic fractures in elderly patients are commonly associated with low-energy trauma such as ground level falls and most are minimally displaced, impacted fractures that can

be treated successfully with non-operative means. However, the optimal surgical management of three and four-part proximal humeral fractures in elderly osteoporotic patients remains controversial, with many advocating prosthetic replacement of the humeral head.

In the elderly, the commonest cause is a fall, while in the younger patients it is associated with vehicular accidents or sporting activity. Osteoporosis predisposes the elderly to this fragility fracture4 Osteoporosis causes an increased risk of fracture through decreased bone mineral density, disruption of bone micro-architecture and reduction in non-collagenous proteins.

Proximal humerus fractures are difficult to manage, particularly in the osteoporotic bone, where the fracture is usually comminuted and the implants have poor purchase.

The most serious fractures and fracture dislocations are often seen in active, middle aged patients. Because of increasing incidence of high velocity trauma, complicated fracture pattern in proximal humerus are becoming increasingly common. It has been always enigma of management because of numerous muscle attachments and paucity of space for fixing implant in fracture of proximal humerus.

For proximal humeral fractures include percutaneous K-wiring, screw fixation, tension band wiring and conventional plates and screws and intramedullary nailing.[7,8] Surgical treatment either by open reduction and internal fixation or prosthetic replacement has been reported being successful, however, there have been concerns with regard to poor bone quality in elderly population

Both operative and non-operative methods are used in management of these injuries with different outcomes. Significant controversy continues regarding the best method of treating displaced fractures. In the past century, non-operative treatment of proximal humeral fractures was documented as an acceptable approach to treatment with modalities such as traction, manipulation and casting are commonly employed.[5,6]

These surgeons emphasized on early functional range of motion, and malunion was deemed acceptable. However, poor functional outcome especially in comminuted fractures was recognized.

In order to avoid poor outcome, the tendency to open reduction and internal fixation became increasingly common. Traditional internal fixation stabilization methods.for proximal humeral fractures include percutaneous K-wiring, screw fixation, tension band wiring and conventional plates and screws and intramedullary nailing.[7,8] Surgical treatment either by open reduction and internal fixation or prosthetic replacement has been reported being successful, however, there have been concerns with regard to poor bone quality in elderly population.

For elderly patients, early recovery and independence in everyday life is a decisive therapy goal. Displaced 3-or 4-part fractures in elderly individuals represent a surgical challenge despite the availability of numerous fixation devices and implants The problems with this type of fractures arise from mechanically unfavorable fragment constellations, the complex anatomy of the rotator cuff, the poor anchoring possibilities for any kind of implant owing to osteoporosis, and the risk of nonunion, soft tissue contractures, periarticular ossifications, infection, and avascular necrosis of the humeral head. The goal of surgery is anatomical and stable reconstruction. An unrestricted, early rehabilitation should ideally lead to a good final functional result, allowing satisfactory daily living.

Proximal humerus fracture management is constantly evolving, particularly in light of improved understanding of fracture characteristics and innovations in surgical technique and technology. The surgery should be carried out as soon as the patient general condition permit. A delay of several days makes reduction more difficult and a significant delay results in absorption of bone, making secure internal fixation impossible.[9]

This prospective study was conducted to analyze fractures of the proximal humerus that were treated with the proximal humerus locking compression plate and documents their clinical and functional outcome.

Aim

To assess the functional outcome of PHILOS(proximal humerus internal locking system) plating in proximal humerus fractures

Aims and Objectives of the study

Aim of the study is to assess functional outcome in displaced proximal humerusfractures with Proximal humerus locking plates(PHILOS PLATE)

- The goal of the study is to test the efficacy and functional outcome of locking plates in proximal humerus fractures.
- To evaluate the incidence of complication that may occur with interlocking plating in proximal humerus fracture
- To know the commonly effected age group in proximal humerus fractures
- To know the incidence of various types of proximal humerus fractures
- To prevent the shoulder stiffness and to achieve good functional shoulder movements
- To study the advantage of a fixed ankle locking system in managing communited fractures of proximal humerus.
- To make suggestions for better management in our setup.

MATERIAL AND METHODS

Twenty five displaced fractures of proximal humerus(in twenty five patients) treated with PHILOS (proximal humerus locking system) plate between MAY 2021 and APRIAL 2023.

The study was conducted in Department of Orthopedics& Traumatology Government General Hospital, Rangaraya Medical College, Kakinada.

Inclusion Criteria

- Patients between 18 to 49 yrs age with proximal humerus fractures
- Patients fit for surgery
- Closed proximal humerus fractures 2,3,4 part according to Neer classification

Exclusion Criteria

- Children and adolescent patients (<19yrs)
- Surgical site infections
- Isolated proximal 1/3rd humerus shaft fractures
- Patients medically unfit for surgery
- Open fractures
- Pathological fractures
- Minimally displaced fractures that can be managed conservatively

Sample Size:25 cases of displaced proximal humerus fractures.

Examination

The patients were examined closely to find out their general condition and other associated injuries.

FIRST AID AND EMERGENCY TREATMENT

1. Analgesia to relieve pain.
2. Intra Venous lines were started in cases of necessity. All those who had open wounds were also given Inj. Tetanus toxoid, IM, and /or Tetanus immunoglobulin as indicated.
3. Splinting of the injured arm was done either in a U slab or arm sling.
4. All patients were given a dose of IV antibiotics prior to surgery.

Investigations

1. X-rays of arm with shoulder joint Antero posterior and lateral views
2. X-rays of other parts injured.
3. Ct scan in complex injuries and injuries with suspicious articular involvement
4. Complete blood picture
5. Biochemical analysis
6. Blood Group and Rh Type
7. ECG for all patients above the age of 40 years.

MANAGEMENT – PROTOCOL

All displaced fractures were treated surgically with open reduction and internal Fixation using PHILOS (Proximal humerus internal locking system)plate.

SURGERY

All the cases were operated under general anaesthesia, in some cases supplemented with brachial block. All the cases were operated in a modification of delto-pectoral approach where instead of developing delto- pectoral plane we go through the substance of deltoid leaving a 1 cm of deltoid intact adjacent to delto-pectoral groove. This modification enabled us for the proper lateral placement of plate,easier reduction of displaced greater tuberocity fracture, and better rotator cuff repair and also to reduce the displaced Greater tuberosity fracture.

Ideal placement of the PHILOS plate is usually 8 mm inferior to upper border of greater tuberocity and 5 mm posterior to bicipital groove. C arm assistance may be utilized to check proper placement of plate and avoid screw penetration.

POST OPERATIVE

1. Most case were given an arm pouche and gentle active pendularexcersises started on 3rd post-operative day. Rigid immobalisation with J Slab was reserved for fixation in communited proximal humerus injuries.
2. Suture removal done at average of 10 days.
3. Pendulum exercises started on 10 th post op day
4. Controlled abduction and flexion beyond 90 degree was allowed by the end of 2nd week.
5. At each follow up patient is examined and evaluated for pain, available range of motion, functional capability, muscle strength and tone.
6. Radiographs were done at 2nd week, 6th week and 12th week to evaluate the progress of fracture union and fracture fixation.

RESULTS

The study of treatment of displaced proximal humerus fractures was conducted in the department of Orthopaedics& Traumatology Government General Hospital, Rangaraya Medical College, Kakinada from MAY 2021 to APRIAL 2023. During this period 25 cases were treated surgically with PHILOS locking plates and follow up, which forms the basis of this dissertation

The following observations were made of the DATA collected from the study.

1) AGE INCIDENCE

The study conducted on age between 18 to 50 yrs. Proximal humerus fractures were found to have high incidence in the 41 to 50 age group. The incidence of the study was as follows.

SEX INCIDENCE

There were 19 males and 6 femalesi.e 76% males and 24 % females.

Males predominated over females in our study. Ratio of males to female was 3:1.

Patients had right sided involvement and 9 patients had left side involvement. No patients had bilateral involvement.

Most of the patients had sustained injury by RTA19 (76%) and 6(24%) patients had Fall. [Table 7]

FRACTURE TYPE

2(8%) of patients had 4part fracture, 4(16%) had 2-part surgical fracture, 1(4%)had 2 part greater tuberocity fracture, 10(40%) had 3-part fracture, 8 had Fracture dislocation.

COMPLICATIONS

3 of our patients had stiffness of shoulder (12%) and one patient had hardware prominence.

MEAN FOLLOW UP OF PATIENTS: 13.5 Months

AVERAGE TIME TO FRACTURE UNION: 12.6 weeks

RANGE OF MOVEMENTS

FLEXION

14 (56%) of patients had flexion between 150-180, 6 patients (24%) had 120-150

And 3 patients (12%) had 90-120, and 2patients (8%) had <90.

ABDUCTION

4(20%) patients had abduction 150-180, 7(35%) patients had each of 120-150 and 90-120 and 2(10%) patients had < 90 of abduction.

EXTERNAL ROTATION

16 patients (64) had 71-90 of External rotation and 8 patients (32%) had 51-70 of ER.

INTERNAL ROTATION

13 (65%) patients had 30-60^0, 7 patients (35%) had 60-90^0 internal rotation.

CONSTANT MURLEY SCORING (CMS)

Patients were assessed by CMS on basis of pain, ADL, ROM, power.

5 Patients (20%) had satisfactory,10 (40%)patients had good results, and 10 patients (40%) had excellent results.

UCLA SCORING

Among 25 patients 4 had fair, 17 had good results,4 excellent results.

Table 1: Constant Murley Score

Pain	**15**
Activities of daily living	20
Range of movements	40
Power	25
Total	100

Table 2: Activity Level

Full work	**4**
Full recreation	4
Unaffected sleep	2
POSITONING	
UP TO WAIST	2
UP TO XIPHOID	4
UP TO NECK	6
UP TO TOP OF HEAD	8
ABOVE HEAD	10

Table 3: Pain

Severe	**0**
Moderate	5
Mild	10
None	15

Table 4: Age distribution of patients studied

Age groups	**No of patients**	**% of patients**
≤20 yrs	2	8
21-30 yrs	4	16
31-40 yrs	9	36
41-50yrs	10	40
Total	**25**	**100.0**
Mean age	37.76	

Table 5: Sex wise distributein of patients studied

Sex	**No of patients**	**% of patients**
Male	19	76
Female	6	24
Total	**25**	**100.00**

Table 6: Site involved

Site involved	**No of patients**	**% of patients**
Left	9	36.00
Right	16	64.00
Total	**25**	**100.00**

Table 7: Mode of Injury

Mode of Injury	**No of patients**	**% of patients**
RTA	19	76
Fall	6	24
Total	25	100.00

Table 8: Fracture type on Neers classification

Fracture type	No of patients	% of patients
2 part surgical neck	4	16
2 part greater tuberosity	1	4
3 part greater tuberosity+ surgical neck	10	40
4 part	2	12
Fracture dislocation	8	32
Total	25	100.00

Table 9: Complications

complications	No.patients	% of patients
Shoulder stiffness	3	12
Hardware problem	1	4
Impingement syndrome	0	0
AVN Humerus head	0	0
Infection	0	0
Implant failure	0	0
nil	21	84
Total	25	100.00

Table 10: Significant Associated Injuries

ASSOCIATED INJURY	NO.CASES
Femur fracture	1
Acetabulum fracture	2
Radius fracture	2
Both bone leg fracture	1
Hip dislocation	1
Lateral condyle fracture tibia+ zygoma fracture	1

Table 11: Flexion

Flexion	No of patients	% of patients
<90	2	8
91-120	3	12
121-150	6	24
151-180	14	56
Total	25	100.00

Table 12: Abduction

Abduction	No of patients	% of patients
≤90	3	12
91-120	4	16
121-150	4	16
151-180	14	56
Total	25	100.00

Table 13: External Rotation

External Rotation	No of patients	% of patients
<30	0	0.00
31-50	1	4
51-70	8	32
71-90	16	64
Total	20	100.00

Table 14: Internal Rotation

Internal Rotation	No of patients	% of patients
≤30	0	0.00
31-50	0	00
51-70	12	48
71-90	13	52
Total	25	100.00

Table 15: CMS

CMS	CMS	No of patients	% of patients
<60	Poor	0	0
61-70	Adequate	0	0
71-80	Satisfactory	5	20
81-90	Good	10	40
91-100	Excellent	10	40
Total		25	100.00

Table 16: UCLA Scoring

SCORE		NO.OF PATIENTS	PERCENTAGE
0-20	POOR	0	0
21-27	FAIR	4	16
28-33	GOOD	17	58
34-35	EXCELLENT	4	16

Table 17: Range of motion (ROM)

Range of motion (ROM)	Minimum	Maximum	Mean
Flexion	80	180	146.8
Abduction	80	170	142.16
External Rotation	50	90	77.2
Internal Rotation	60	90	74.8
CMS	71	98	87.4
UCLA	26	34	30.96

Table 18: Mean of Movement and Score Age Group Wise

S.NO.	AGE GROUPS	MEAN FORWARD FLEXION	MEAN ABDUCTION	MEAN EXTERNAL ROTATION	MEAN INTERNAL ROTATION	MEAN CMS	MEAN UCLA
1	≤20 Yrs	165	170	90	80	96	33
2	21-30 Yrs	160	158	83	78	90	32
3	31-40 Yrs	142	134	74	73	84	30
4	41-50 Yrs	143	140	78	74	87	31

DISCUSSION

The incidence of proximal humerus fractures has increased in last few years due to changes in life style and increase in road traffic accidents when compared to the previous decade. Treatment option of proximal humerus fractures were restricted to T-butress plate, K-wires,TBW etc… however the best management in these injuries is still uncertain. Most of the proximal humerus fracture which are undisplaced can be treated conservatively. Even if the injury is thoroughly analyzed and the literature is understood, treatment of displaced fracture or fracture dislocation is difficult.

Many studies have shown that the displaced fracture of the proximal humerus when left untreated have a poor prognosis.[10,11,12]However, with the aim of getting anatomically accurate P reductions, rapid healing and early restoration of function, which is a demand of today's life, open reduction and internal fixation, is the preferred modality of treatment. This goal is well achieved by locking compression plate as depicted in our study.

The present study was conducted to assess the results of two part, three part and four proximal humeral fracture treatedby open reduction internal fixation by locking compression plate.

AGE INCIDENCE

Proximal humerus fractures occur more commonly in middle age group.

Numerous age related studies point towards this and our study is consistent with this finding.

In our study(conducted between 18-50 yrs) majority of the patients i.e. 10 (40%) were from age Group of 41 to 50 years followed by 9 patients (36%) in between31-40 yrs. The Average age of patient was 37.7 yrs. Majority of the patient in our group are middle aged in our study probably that is most active and working group of the population in general. This observation is comparable with other studies.

SEX INCIDENCE

Further as with other studies, our study showed a higher incidence of fractures in men than in women. The gender ratio was 3: 1.This higher ratio can be explained by a higher involvement of male in day to day activities in compare to female.

MODE OF INJURY

Major cause of fracture in our study was RTA in 19 cases (76%), and in 6 cases (24%) the mode of injury was Fall.

MA Fazal,FS Haddad in their study have reported 21 cases(77.8%) of fall and 6cases(22.2%) of RTASameer aggarwal,kamalbali in their study of 47 patients of proximal humerus fracture,fall accounted for 55% of fracture, road side accident 42.5% and 1 fracture(2.5%) was caused by seizure.

Herbert Resch et al in their study of 27 patients with 3 part and four-part fracture, 24 patients had history of high energy trauma.

Our centre being cosmopolitan with lot of heavy vehicular traffic density (pcu/min) RTA is major cause and is comparable to other studies originated from other city based studies.

SIDE AFFECTED

In our present study fracture occurred on right side in 16 patients and on left side in 9 patients. C. Gerber reported, in their series of 34 fractures 16 were on left side and 18 were on right side36P.

It corresponds to the normal right hand dominant strain of human beings and it is used to prevent from fall and subsequently after impact.

There were total four complications in four patient. 3case had shoulder stiffness and another case hard ware prominence.

We did not encounter even a single case of screw loosening or screw back out within these 25 cases, signifies the stability of locking plate construct.

Mean follow up our study is 13.5 months ranging from 8 months to 18 months. Average time for union was 12.6 weeks in our study ranging from 12 weeks to 16 weeks.

We have operated all our cases through a modification of delto-pectoral approach where instead of developing delto-pectoral plane we go through the substance of deltoid leaving a 1 cm of deltoid intact adjacent to delto-pectoral groove. This modification enabled us for the proper lateral placement of plate and also to reduce the displaced Greater tuberosity fracture.

Loss of vascularity of humoral head is neither related to age nor the type of NEER'S fracture but more to the available medial sleeve of soft tissue and it's integrity.

As per our study range of motion is affected by increase in age, severity of fracture pattern, poor compliance to rehabilitation, rigidity of fixation.

Range of motion is affected by increasing age in our study, best range of motion is found in age group of 20 – 30 years with a mean of 160 degrees forward flexion, 150 degrees abduction, 83degrees of external rotation and 78 degrees of internal rotation. Range of motion reduced with advancing age in our study can probably explained by the age related Rotator cuff degeneration.

Range of motion is also influenced by fracture pattern with best results in isolated greater tuberosity fractures and with least in fracture dislocations.

Functional outcome is also influenced by pattern of fracture with best results in isolated 2-part greater tuberosity fracture (Constant-Murley score – 9 1) followed by 2-part surgical neck fractures (90) and 4-part fracture 80.

Results were evaluated based on the CONSTANT MURLEY SOCRE AND UCLA shoulder scoring systems.

We had good to excellent results in 80%(20)and 20% (5)satisfactory results according to constant murley scoring system.

84%of patients (21) had good to excellent results,16%(4%) had fair results according to UCLA Scoring.

STUDY	AGE OF PATIENT	MEAN AGE
C.Gerber,C.M.L.Werner[13]	16-73	44.9
MA Fazal,FS Haddad[14] P[P]	22-85	56
Sameer aggarwal,kamal Bali[15]	23-81	58.1
Our Study	**18-50**	**37.7**

STUDY	MALE	FEMALE
C.Gerber,C.M.L.Werner[13]	1.35	1
MA Fazal,FS Haddad[14]	1	3.5
Sameer aggarwal,kamal Bali[15]	1.7	1
Our study	**3**	**1**

Mode of injury	RTA	FALL
MA Fazal[14]	6	21
Herbert Resc[16 P]	24	3
Our study	**19**	6

Table: Fracture Pattern and Method of Treatment Used by Different Study Series

AUTHOR	YEAR	NO OF CASES	2 PART	3 PART	4 PART	AVERAGE AGE	METHOD
Felix Brunner[17]	2009	157	49	70	38	65	ORIF with PHILOS plate
MA Fazal[14]	2009	27	13	12	2	56	ORIF with PHILOS plate
Our study	2021	25	6	14	5	42	ORIF with PHILOSPlate

ROM	RANGE	AVERAGE
FLEXION	80-180	146.8
ABDUCTION	80-180	142.5
EXTERNAL ROTATION	50-90	77.2
INTERNAL ROTATION	50-90	74.8

CONCLUSION

In conclusion proximal humerus internal locking system (PHILOS) is mechanically and biologically an advantageous implant in proximal humeral fractures particularly in comminuted fractures and in osteoporotic bones in elderly patients, thus allowing early mobilization.

Conflict of Interest: None

Funding Support: Nil

REFERENCES

1. Anthony F, Depalma, Richards Cautilli, “Fractures of the upper end of the humerus”; Clin.ortho.20,1971:73-93.
2. Neer CS II, Rockwood CA, Fractures and dislocations of the shoulder,in Rockwood CA,Green DP (eds):Fracture in adults, Philadelphia, PA,Lippincott, 1984:675-721.
3. Baron JA, Barrett JA, Karagas MR. The epidemiology of peripheral fractures.Bone. 1996;18(3 Suppl):209S-213S
4. Brien H. Neer´s classification system: a critical appraisal. J Trauma 1995; 38(2):257–60.
5. Court-Brown CM. The epidemiology of proximal humeral fractures.ActaOrthopScand 2001; (72 (4)):365–71.
6. Caldwell, J.A. and Smith, J. Treatment of unimpacted fractures of the surgical neck of the humerus. Am. J. Surg. 1936; 31: 141-144.
7. Frankau, C. A manipulative method for the reduction of fractures of the surgical neck of the humerus. Lancet.1933; 2:755.
8. C.P. Charalambous,I.siddiqe, ”Proximal humerus internal locking for the treatment of proximal humerusfracture”Archorthop trauma (2007)127: 205
9. CanaleST, BeatyJH, Daugherty K, Jones L, Campbells operative orthopaedics; Fracture about proximal humerus in adults. 10th Ed., Vol – 3: 2990 – 2994.
10. Zyto K, Ahrengart L, Sperber A, et al. Treatment of displaced proximal humeral fractures in elderly patients. J Bone Joint Surg Br 1997; 79:412-417
11. Gerald R. Williams, Kirk L. Wong, 2000, “Two-part and three part fracturesManagement of proximal and distal humerus fracture”. OrthopClin North Am, January 31 (1): 1-21.
12. Scott E, Powell, Robert W, Chandler, Fractures of the proximal humerus, Chapter-11, In Text book of Operative techniques in upper extremity sports injuries. Ed.Frank, W. Jobe, Mosby, 1995: p.313-340.
13. Georg osterhoff, Christianossendorf, “The calcar screwing angular stable plate fixation of proximal humerus fractures-a case study” journal of orthopedic surgery and research 2011,6:50.
14. MAFazal, FS Haddad, “PHILOS plate fixation for displaced proximal humeral fractures” journal of orthopaedic surgery2009;200917(1)15-8.
15. SameerAggarwal, “Displaced proximal humeral fractures: An Indian experience with locking plate”Journal of Orthopaedic surgery and research2010,5:60
16. P.C. Strohm,P.Helwig, “Locking Plates in Proximal HumerusFractures”ACTA 74, 2007, p. 410–415.
17. Ramchander, Siwach, Roop Singh, Rajesh, Kumar, Rohilla, Internal fixation of proximal humerus fracture by locking proximal humerus plate in elderly osteoporotic, J OrthopaedTraumatol (2008) 9:149–153.