

A Study on Outcome of Proximal Humerus Fracture in Adults Treated with Open Reduction and Internal Fixation using Proximal Humerus Locking Plate

Rohit Jatra¹, Lalit Jain², Shubham Choithwani³, Rishabh Gulabwani⁴, Shubham Gabhane⁵, Pankaj Dhabalia⁶, Suman Kumar Nag⁷

¹D Ortho, Post Diploma DNB Resident, Department of Orthopaedics, Ramkrishna Care Hospital, Raipur, Chhattisgarh, India

^{2,7}MS Ortho, Consultant, Department of Orthopaedics, Ramkrishna Care Hospital, Raipur, Chhattisgarh, India

^{3,5}Resident, Department of Orthopaedics, Ramkrishna Care Hospital, Raipur, Chhattisgarh, India

⁴DNB Ortho, Senior Resident, Department of Orthopaedics, SMS Multispecialty Hospital, Ahmedabad, Gujarat, India

⁶MS Ortho, Head of Department of Orthopaedics, Ramkrishna Care Hospital, Raipur, Chhattisgarh, India

Received: 01-04-2026 / Revised: 15-05-2026 / Accepted: 21-06-2026

Corresponding author: Dr. Rohit Jatra

Conflict of interest: Nil

Abstract

Background: Proximal humerus fractures are among the most common fractures of the upper extremity and are frequently encountered in both elderly individuals with osteoporotic bone and younger adults following high-energy trauma. Open reduction and internal fixation (ORIF) using a proximal humerus locking plate (PHILOS) has become a widely accepted treatment option for displaced fractures because of its ability to provide stable fixation and facilitate early mobilization. However, evaluation of functional recovery, radiological healing, and postoperative complications remains essential to determine the effectiveness of this treatment modality.

Aim: To evaluate the functional and radiological outcomes of proximal humerus fractures in adults treated with open reduction and internal fixation using a proximal humerus locking plate.

Methods: A prospective observational study was conducted in the Department of Orthopaedic Surgery at Ramkrishna Care Hospital, Raipur, Chhattisgarh, from April 2025 to March 2026. A total of 40 adult patients with proximal humerus fractures underwent ORIF using a proximal humerus locking plate. Patients were followed for six months. Clinical outcomes were assessed using the Visual Analogue Scale (VAS), Constant–Murley Score, and Disabilities of the Arm, Shoulder and Hand (DASH) Score, while radiological union and postoperative complications were evaluated at regular follow-up intervals. Data were analyzed using SPSS version 26.0. Repeated measures ANOVA was used for comparison of continuous variables, and a p-value of <0.05 was considered statistically significant.

Results: The mean VAS score significantly decreased from 7.02 ± 0.69 at baseline to 1.07 ± 0.72 at six months ($p < 0.001$). The mean Constant–Murley score improved significantly from 37.45 ± 2.77 to 77.67 ± 3.92 ($p < 0.001$), while the mean DASH score decreased from 72.82 ± 6.12 to 20.67 ± 2.21 ($p < 0.001$). Radiological union was achieved in 90% of patients by three months, and complete fracture consolidation was observed in 100% of patients at six months. Postoperative complications were minimal, with only isolated cases of stitch line infection, stiffness, malunion, and avascular necrosis observed during follow-up.

Conclusion: Open reduction and internal fixation using a proximal humerus locking plate is a safe and effective treatment modality for proximal humerus fractures in adults. The procedure provides excellent pain relief, significant functional improvement, satisfactory radiological healing, and a low complication rate, supporting its role as a reliable option for the surgical management of displaced proximal humerus fractures.

Keywords: Proximal Humerus Fracture, Open Reduction And Internal Fixation, PHILOS Plate, Functional Outcome.

DOI: 10.25258/ijcpr.18.7.2

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Proximal humerus fractures (PHFs) are among the most common fractures involving the upper extremity, accounting for approximately 4–6% of all fractures in adults and representing the third most frequent osteoporotic fracture after hip and distal radius fractures. The incidence of these injuries has increased steadily over recent decades, primarily due to population aging, increasing life expectancy, and the rising prevalence of osteoporosis. While elderly individuals commonly sustain proximal humerus fractures following low-energy falls, younger adults usually experience these injuries after high-energy trauma such as road traffic accidents, sports injuries, or falls from height. This bimodal distribution highlights the influence of both bone quality and injury mechanism on fracture morphology and subsequent management strategies [1,2].

The proximal humerus is an anatomically complex region that plays a pivotal role in shoulder mobility and upper limb function. It consists of the humeral head, greater tuberosity, lesser tuberosity, and surgical neck, with its stability maintained by the rotator cuff musculature and surrounding ligamentous structures. The vascularity of the humeral head is primarily supplied by the anterior and posterior circumflex humeral arteries, making displaced fractures particularly vulnerable to vascular compromise and avascular necrosis. Preservation of soft tissue attachments and restoration of anatomical alignment therefore remain fundamental principles during surgical intervention [3,4].

Accurate fracture classification is essential for treatment planning and prognostication. The Neer classification system remains the most widely accepted classification for proximal humerus fractures and categorizes injuries according to the displacement of four anatomical segments. One-part fractures are generally managed conservatively with immobilization and early rehabilitation, whereas displaced two-, three-, and four-part fractures frequently require operative intervention to restore joint congruity, maintain stability, and optimize functional recovery. Although the Neer classification has certain limitations regarding interobserver reliability, it continues to serve as the standard framework in both clinical practice and orthopedic research [5].

Open reduction and internal fixation (ORIF) using locking compression plates, particularly the Proximal Humerus Internal Locking System (PHILOS), has become one of the most widely accepted treatment modalities for displaced proximal humerus fractures. Locking plate technology offers angular stability, improved

fixation in osteoporotic bone, and superior resistance to varus collapse when compared with conventional plating systems. These biomechanical advantages facilitate early mobilization, maintain fracture reduction, and promote fracture healing while minimizing secondary displacement. Consequently, PHILOS plating has gained widespread acceptance for managing complex proximal humerus fractures in adults [6,7].

Despite these advantages, complications following locking plate fixation continue to be reported. Common postoperative complications include screw cut-out, intra-articular screw penetration, varus malunion, subacromial impingement, infection, implant failure, non-union, and avascular necrosis of the humeral head. The occurrence of these complications is influenced by several factors including fracture complexity, osteoporosis, inadequate medial calcar support, improper implant positioning, and surgical technique. Therefore, meticulous preoperative planning, accurate fracture reduction, restoration of medial support, and appropriate implant placement remain critical determinants of successful outcomes [8].

Recent advances in surgical techniques and implant design have improved the clinical results of locking plate fixation. Contemporary evidence suggests that proper plate positioning approximately 5–8 mm distal to the greater tuberosity, use of inferomedial calcar screws, restoration of medial column support, and preservation of soft tissue vascularity significantly reduce fixation failure and improve long-term shoulder function. These technical considerations have become essential components of modern operative management protocols for displaced proximal humerus fractures [9].

Evaluation of treatment outcomes extends beyond fracture union alone and includes assessment of pain relief, restoration of shoulder motion, upper limb function, radiological healing, and patient satisfaction. Standardized outcome measures such as the Constant–Murley Score, Disabilities of the Arm, Shoulder and Hand (DASH) score, and Visual Analogue Scale (VAS) are widely used to objectively evaluate postoperative recovery. Radiological assessment focuses on fracture union, maintenance of reduction, implant position, and complications, thereby providing a comprehensive evaluation of treatment effectiveness [10]. Although several international studies have demonstrated encouraging outcomes following ORIF with PHILOS plating, variations in patient demographics, fracture characteristics, bone quality, surgical expertise, rehabilitation protocols, and healthcare infrastructure continue to influence clinical results. Furthermore, evidence from

developing countries remains relatively limited. Therefore, continued evaluation of functional and radiological outcomes in different clinical settings is necessary to strengthen existing evidence and optimize treatment strategies. The present study was undertaken to evaluate the functional and radiological outcomes of proximal humerus fractures in adults treated with open reduction and internal fixation using a proximal humerus locking plate.

Material and Methods

The present prospective observational study was conducted in the Department of Orthopaedic Surgery at Ramkrishna Care Hospital, Raipur, Chhattisgarh, over a period of 12 months from April 2025 to March 2026. The study included adult patients presenting with proximal humerus fractures who underwent open reduction and internal fixation (ORIF) using a proximal humerus locking plate (PHILOS). Consecutive eligible patients admitted during the study period were enrolled after obtaining written informed consent.

Patients aged 18 years and above with closed proximal humerus fractures who were willing to participate and comply with follow-up were included in the study. Patients with open fractures, pathological fractures (excluding osteoporotic fractures), polytrauma with associated injuries affecting rehabilitation, head injury impairing functional assessment, and those unwilling or unable to provide informed consent were excluded.

A detailed clinical history was obtained for all patients, including age, sex, mechanism of injury, affected side, dominant limb, and associated comorbidities such as diabetes mellitus, hypertension, and osteoporosis. General and local clinical examinations were performed, with particular attention to neurovascular status and axillary nerve function. Radiological evaluation included standard shoulder radiographs comprising anteroposterior, scapular Y, and axillary views. Computed tomography was performed in selected cases with complex fracture patterns. Fractures were classified according to the Neer classification system.

All patients underwent open reduction and internal fixation using a proximal humerus locking plate under appropriate anaesthesia following standard surgical principles. The choice of surgical approach was based on fracture configuration and surgeon preference. Intraoperative details including surgical approach, duration of surgery, and intraoperative complications were recorded. Standard postoperative rehabilitation protocols were followed for all patients.

Patients were followed up at baseline, 6 weeks, 3 months, and 6 months after surgery. Clinical assessment included pain evaluation using the

Visual Analogue Scale (VAS), functional assessment using the Constant–Murley Score and Disabilities of the Arm, Shoulder and Hand (DASH) score, and assessment of shoulder range of motion. Radiological evaluation was performed at each follow-up visit to assess fracture union, implant position, maintenance of reduction, and postoperative complications including malunion, implant failure, infection, and avascular necrosis. Patient satisfaction was also documented at the final follow-up.

The collected data were entered into Microsoft Excel and analysed using the Statistical Package for the Social Sciences (SPSS) software, version 26.0. Continuous variables were expressed as mean \pm standard deviation, whereas categorical variables were presented as frequencies and percentages. Comparison of continuous variables across different follow-up intervals was performed using repeated measures analysis of variance (ANOVA). Categorical variables were analysed using the Chi-square test or Fisher's exact test wherever appropriate. A p-value of less than 0.05 was considered statistically significant.

The study was conducted after obtaining approval from the Institutional Ethics Committee of Ramkrishna Care Hospital, Raipur. Written informed consent was obtained from all participants prior to enrolment. Confidentiality of patient information was maintained throughout the study, and all study procedures were performed in accordance with the ethical principles of the Declaration of Helsinki.

Results

The present study was conducted to evaluate the functional and radiological outcomes of proximal humerus fractures in adult patients treated with open reduction and internal fixation (ORIF) using a proximal humerus locking plate (PHILOS).

The age-wise distribution of the study subjects revealed that the majority of patients belonged to the 31–40 years age group, accounting for 45% (n=18) of the total population. This was followed by the 51–60 years age group, which comprised 22.5% (n=9) of the subjects. Patients aged above 60 years constituted 17.5% (n=7), indicating a considerable proportion of elderly individuals.

The younger age group of less than 30 years included 12.5% (n=5) of the patients. In contrast, the 41–50 years age group had the least representation, contributing only 2.5% (n=1) of the total study population. Overall, the findings suggested that proximal humerus fractures were more commonly observed in the middle-aged population, particularly in the 31–40 years age group, followed by older individuals above 50 years. (Table 1) The gender-wise distribution of the study subjects showed that the majority were male

patients, accounting for 55% (n=22) of the total study population, while female patients constituted 45% (n=18). This indicates a slight male predominance in the occurrence of proximal humerus fractures in the present study. (Table 2) Table 3 shows the comparison of Visual Analogue Scale (VAS) scores at baseline, 6 weeks, 3 months, and 6 months following open reduction and internal fixation using a proximal humerus locking plate. The mean VAS score decreased progressively from 7.02 ± 0.69 at baseline to 5.12 ± 0.72 at 6 weeks, 3.15 ± 0.66 at 3 months, and 1.07 ± 0.72 at 6 months. Statistical analysis using repeated measures ANOVA demonstrated that this reduction in pain over time was highly statistically significant ($F = 529.50, p < 0.001$).

Table 4 demonstrates the comparison of Constant–Murley scores at baseline and subsequent follow-up visits. The mean Constant–Murley score improved steadily from 37.45 ± 2.77 at baseline to 46.22 ± 3.59 at 6 weeks, 63.32 ± 3.54 at 3 months, and 77.67 ± 3.92 at 6 months, indicating progressive improvement in shoulder function. The difference across follow-up periods was highly statistically significant ($F = 1057.23, p < 0.001$). Table 5 presents the comparison of Disabilities of the Arm, Shoulder and Hand (DASH) scores at baseline, 6 weeks, 3 months, and 6 months. The mean DASH score decreased from 72.82 ± 6.12 at baseline to

50.72 ± 1.86 at 6 weeks, 35.02 ± 2.20 at 3 months, and 20.67 ± 2.21 at 6 months, reflecting significant improvement in upper limb function and reduction in disability. This improvement was found to be highly statistically significant ($F = 1576.34, p < 0.001$). Table 6 depicts the radiological union status at different follow-up intervals. At baseline, all patients (100%) had radiological evidence of fracture. At 6 weeks, 92.5% of patients demonstrated soft callus formation, while 7.5% showed hard callus formation. By 3 months, fracture union had been achieved in 90% of patients, whereas 10% exhibited delayed union. At the 6-month follow-up, complete radiological consolidation was observed in 100% of the study participants, indicating satisfactory fracture healing.

Table 7 illustrates the distribution of postoperative complications during follow-up. At 6 weeks, stitch line infection was observed in 10% of patients, while 90% had no complications. At 3 months, only 7.5% of patients experienced shoulder stiffness, whereas the remaining patients had no complications. At the final follow-up of 6 months, complications were minimal, with 2.5% each developing stiffness, malunion, and avascular necrosis, while 92.5% of patients remained free from complications, indicating a favorable postoperative outcome.

Table 1: Descriptive statistics showing age-wise distribution of study subjects

| Age | Frequency | Percentage (%) |
|--------------|-----------|----------------|
| <30 Years | 5 | 12.5 |
| 31-40 years | 18 | 45 |
| 41-50 years | 1 | 2.5 |
| 51-60 years | 9 | 22.5 |
| >60 years | 7 | 17.5 |
| Total | 40 | 100 |

Table 2: Descriptive statistics showing gender-wise distribution of study subjects

| Gender | Frequency | Percentage (%) |
|--------------|-----------|----------------|
| Male | 22 | 55 |
| Female | 18 | 45 |
| Total | 40 | 100 |

Table 3: Comparison of VAS score at baseline, 6 weeks, 3 months and 6 months

| VAS Scale | Mean \pm SD | F-value | p-value |
|-----------|-----------------|---------|---------|
| Baseline | 7.02 ± 0.69 | 529.50 | <0.001* |
| 6 weeks | 5.12 ± 0.72 | | |
| 3 months | 3.15 ± 0.66 | | |
| 6 months | 1.07 ± 0.72 | | |

*ANOVA; statistically significant.

Table 4: Comparison of Constant–Murley score at baseline, 6 weeks, 3 months and 6 months

| Constant–Murley Score | Mean \pm SD | F-value | p-value |
|-----------------------|------------------|---------|---------|
| Baseline | 37.45 ± 2.77 | 1057.23 | <0.001* |
| 6 weeks | 46.22 ± 3.59 | | |
| 3 months | 63.32 ± 3.54 | | |
| 6 months | 77.67 ± 3.92 | | |

*ANOVA; statistically significant.

Table 5: Comparison of DASH score at baseline, 6 weeks, 3 months and 6 months

| DASH Score | Mean \pm SD | F-value | p-value |
|------------|------------------|---------|---------|
| Baseline | 72.82 \pm 6.12 | 1576.34 | <0.001* |
| 6 weeks | 50.72 \pm 1.86 | | |
| 3 months | 35.02 \pm 2.20 | | |
| 6 months | 20.67 \pm 2.21 | | |

*ANOVA; statistically significant

Table 6: Distribution of radiological union at different follow-up intervals

| Follow-up | Radiological Union | Frequency | Percentage |
|-----------|------------------------|-----------|------------|
| Baseline | Fracture | 40 | 100 |
| 6 weeks | Soft callus | 37 | 92.5 |
| | Hard callus | 3 | 7.5 |
| 3 months | Union achieved | 36 | 90 |
| | Delayed union | 4 | 10 |
| 6 months | Complete consolidation | 40 | 100 |

Table 7. Comparison of complications at different follow-up intervals

| Complications | 6 Weeks n (%) | 3 Months n (%) | 6 Months n (%) |
|--------------------------|---------------|----------------|----------------|
| None | 36 (90.0) | 37 (92.5) | 37 (92.5) |
| Stitch line infection | 4 (10.0) | 0 (0) | 0 (0) |
| Stiffness | 0 (0) | 3 (7.5) | 1 (2.5) |
| Malunion | 0 (0) | 0 (0) | 1 (2.5) |
| Avascular necrosis (AVN) | 0 (0) | 0 (0) | 1 (2.5) |

Discussion

The present prospective observational study evaluated the functional and radiological outcomes of proximal humerus fractures in adults treated with open reduction and internal fixation using a proximal humerus locking plate (PHILOS). The findings demonstrated significant improvement in pain, shoulder function, upper limb disability, and radiological union throughout the six-month follow-up period. The reduction in VAS scores, improvement in Constant–Murley scores, and decline in DASH scores, and high rate of fracture union suggest that PHILOS plating provides stable fixation and facilitates early rehabilitation with satisfactory clinical outcomes.

The predominance of patients in the 31–40 years age group in the present study may be attributed to increased exposure to high-energy trauma such as road traffic accidents and occupational hazards in this economically active population. Similar findings were reported by Trikha et al., who observed a higher incidence of proximal humerus fractures among younger adults due to high-energy mechanisms [11]. The slight male predominance observed in the present study may be attributed to increased exposure of males to high-energy trauma, occupational activities, and road traffic accidents.

Pain is an important determinant of postoperative recovery following proximal humerus fracture fixation. In the present study, VAS scores showed a significant decline from baseline to six months, indicating progressive pain relief after surgery. Similar observations were reported by Yang et al., who demonstrated comparable pain reduction

following locking plate fixation in both younger and elderly patients, emphasizing the effectiveness of stable fixation and structured rehabilitation in improving postoperative recovery [9].

The present study demonstrated a marked improvement in Constant–Murley scores over successive follow-up visits, indicating significant restoration of shoulder function. These findings are consistent with those reported by Schulte et al., who observed satisfactory functional recovery following proximal humerus locking plate fixation, with progressive improvement in shoulder mobility and functional performance during follow-up [12]. The improvement in functional outcomes may be attributed to stable fixation, anatomical reduction, and early mobilization following surgery.

Radiological assessment showed progressive fracture healing, with complete consolidation achieved in all patients by the final follow-up. Restoration of fracture stability and maintenance of reduction are essential for successful healing. Similar findings were reported by Hertel et al., who emphasized that preservation of vascularity and anatomical reduction are important predictors of fracture union and prevention of humeral head ischemia after proximal humerus fractures [13]. Their observations support the excellent radiological healing observed in the present study.

The incidence of postoperative complications in the present study was low. Early stitch line infections resolved with appropriate management, while only isolated cases of stiffness, malunion, and avascular necrosis were observed during follow-up. These findings compare favorably with the systematic

review by Sproul et al., which reported that although locking plate fixation is associated with certain complications, most patients achieve satisfactory functional outcomes when appropriate surgical techniques and postoperative rehabilitation are followed [7]. Careful surgical planning and adherence to fixation principles likely contributed to the low complication rate observed in the present study.

The favorable clinical outcomes observed in this study further support the use of locking plate fixation as an effective treatment modality for displaced proximal humerus fractures. Ricchetti et al. highlighted that locking plate technology provides angular stability, particularly in osteoporotic bone, allowing secure fixation and facilitating early rehabilitation with improved functional outcomes [6]. The significant improvement in pain, functional scores, and radiological union observed in the present study reinforces these findings and demonstrates the reliability of PHILOS plating in adult proximal humerus fractures [14,15]

Limitations

The present study has certain limitations that should be considered while interpreting the results. Firstly, the sample size was relatively small (n=40), which may limit the generalizability of the findings to a larger population. Secondly, the study was conducted at a single tertiary care center, which may introduce institutional bias and may not reflect outcomes in different healthcare settings.

The follow-up duration was limited to 6 months, which may not be sufficient to assess long-term complications such as avascular necrosis, implant failure, or late functional outcomes. Additionally, the study lacked a control or comparison group, making it difficult to directly compare the effectiveness of PHILOS plating with other treatment modalities. Variability in patient factors such as bone quality, fracture complexity, and compliance with physiotherapy could also have influenced the outcomes. Lastly, some outcome measures, particularly patient-reported scores, may be subject to observer and reporting bias.

Conclusion

Open reduction and internal fixation using a proximal humerus locking plate is a safe and effective treatment option for proximal humerus fractures in adults. The procedure resulted in significant reduction in pain, progressive improvement in shoulder function, decreased upper limb disability, and satisfactory radiological union over the six-month follow-up period. The overall complication rate was low, with only a few manageable postoperative complications observed. These findings indicate that PHILOS plating

provides stable fixation, facilitates early mobilization, and achieves favorable functional and radiological outcomes. Careful patient selection, meticulous surgical technique, and adherence to structured rehabilitation protocols remain essential for optimizing treatment outcomes.

References

1. Brunner F, Sommer C, Bahrs C, Heuwinkel R, Hafner C, Rillmann P, et al. Open reduction and internal fixation of proximal humerus fractures using a proximal humeral locked plate: a prospective multicenter analysis. *J Orthop Trauma*. 2009;23(3):163-72.
2. Drosdowech DS, Faber KJ, Athwal GS. Open reduction and internal fixation of proximal humerus fractures. *Orthop Clin North Am*. 2008;39(4):429-39.
3. Konrad G, Bayer J, Hepp P, Voigt C, Oestern H, Käab M, et al. Open reduction and internal fixation of proximal humeral fractures with use of the locking proximal humerus plate. Surgical technique. *J Bone Joint Surg Am*. 2010;92 Suppl 1 Pt 1:85-95.
4. Südkamp N, Bayer J, Hepp P, Voigt C, Oestern H, Käab 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(6):1320-8.
5. Ong CC, Kwon YW, Walsh M, Davidovitch R, Zuckerman JD, Egol KA. Outcomes of open reduction and internal fixation of proximal humerus fractures managed with locking plates. *Am J Orthop (Belle Mead NJ)*. 2012;41(9):407-12.
6. Ricchetti ET, Warrender WJ, Abboud JA. Use of locking plates in the treatment of proximal humerus fractures. *J Shoulder Elbow Surg*. 2010;19(2 Suppl):66-75.
7. Sproul RC, Iyengar JJ, Devcic Z, Feeley BT. A systematic review of locking plate fixation of proximal humerus fractures. *Injury*. 2011;42(4):408-13.
8. Omid R, Trasolini NA, Stone MA, Namdari S. Principles of locking plate fixation of proximal humerus fractures. *J Am Acad Orthop Surg*. 2021;29(11):e523-e535.
9. Yang TC, Su YP, Chang MC. The elderly have similar outcomes compared to younger patients after ORIF with locking plate for comminuted proximal humerus fracture. *Acta Orthop Traumatol Turc*. 2019;53(1):1-5.
10. Barlow JD, Logli AL, Steinmann SP, Sems SA, Cross WW, Yuan BJ, et al. locking plate fixation of proximal humerus fractures in patients older than 60 years continues to be associated with a high complication rate. *J Shoulder Elbow Surg*. 2020;29(8):1689-94.

11. Trikha V, Singh V, Choudhury B, Das S. Retrospective analysis of proximal humeral fracture-dislocations managed with locked plates. *J Shoulder Elbow Surg.* 2017 Oct; 26(10):e293-e299. doi: 10.1016/j.jse.2017.03.035.
12. Schulte LM, Matteini LE, Neviasser RJ. Proximal periarticular locking plates in proximal humeral fractures: functional outcomes. *J Shoulder Elbow Surg.* 2011;20(8): 1234-40.
13. Hertel R, Hempfing A, Stiehler M, Leunig M. Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. *J Shoulder Elbow Surg.* 2004;13(4):427-33.
14. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. *Injury.* 2006; 37(8):691-7.
15. Kannus P, Palvanen M, Niemi S, Parkkari J, Järvinen M. Epidemiology of osteoporotic pelvic fractures in elderly people in Finland: sharp increase in 1970-1997 and alarming projections for the new millennium. *Osteoporos Int.* 2000;11(5):443-8.