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Original research article

Analysis of the results of internal fixation for fractures of the proximal humerus

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Abstract

Background and objectives: Four to five percent of fractures are proximal humerus fractures, which also account for forty-five percent of humeral fractures. This study aims to assess and analyze the functional outcomes of proximal humerus fractures that were managed using internal fixation.

Material and Methods: The present investigation was carried out in the Department of Orthopaedics, Andhra Medical College, Vishakhapatnam, Andhra Pradesh, India. This study is a prospective investigation conducted between January 2021 to December 2022, using a sample size of 20 cases. In this study, proper informed permission was gained from every patient involved, ensuring that they were fully aware of the nature and purpose of the research and voluntarily agreed to participate.

Results: The management of complicated humeral fractures with three or four parts poses a significant clinical difficulty. In order to achieve optimal outcomes, it is imperative for the surgeon to attain precise anatomical alignment and secure fixation, while simultaneously minimizing the potential risk of avascular necrosis of the Humeral head through diligent protection of the surrounding soft tissues. The existing body of literature widely agrees that achieving a favorable functional outcome in shoulder fractures is contingent upon two key factors: anatomical reduction of the fracture and a stable fixation, regardless of the specific surgery and implant employed. Additionally, the prompt commencement of functional rehabilitation plays a crucial role in achieving this desired outcome.

Conclusion: The role of the learning curve associated with the chosen implants is undoubtedly significant. The implementation of a proficient surgical approach is crucial in order to mitigate problems, while a rigorous rehabilitation regimen is essential to optimize the outcome. Typically, fractures that involve two or three parts can be managed through the utilization of open reduction and internal fixation techniques.

Keywords: Proximal humerus fractures, internal fixation, and outcome analysis

Introduction

About 4-5% of all fractures are in the proximal humerus, making it a sizable subset of the larger category. In addition, they account for a sizable share of all humeral fractures. The figure jumps to 76% when only individuals aged 40 and up are considered [1]. These fractures have a bimodal age distribution, with younger people and those who have had high-energy trauma making up one group, and older people and those who have suffered low-velocity injuries, like a simple fall, making up the other. Most proximal humerus fractures are non-displaced or have minimal disruption of the bone, making them amenable to non-operative treatment [2, 4].

In 460 BC, Hippocrates was the first to document a proximal humerus fracture and use traction as a therapy. In an effort to improve therapy for proximal humerus fractures, Kocher began categorizing these injuries in 1869. In 1934, Codman developed a classification scheme in which the proximal humerus was divided into four sections depending on the presence or absence of epiphyseal lines. In 1970, Neer added anatomic, biomechanical, and therapeutic dimensions to the previously 4-part model. The diagnostic and therapeutic processes for patients with such fractures benefited greatly from this system. In the beginning, patients were treated with closed reduction, traction, casting, and abduction splints [5, 7].

During the initial years of the 1930s, there was a surge in the use of operational interventions for the management of displaced fractures. This trend persisted throughout the subsequent decades of the 1940s and 1950s. The introduction of humeral head replacement for severely displaced fractures of the

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proximal humerus occurred in the 1950s [8]. During the 1970s, the AO/ASIF group gained significant recognition for their widespread use of plates and screws as a means of addressing fractures. Additionally, there was a notable redesign of humeral head prosthesis during this period. Presently, there is a growing trend towards the utilization of fixation techniques that encompass restricted fixation and limited dissection. Additionally, there is ongoing progress in the enhancement of prosthetic replacement procedures for severe fractures [9, 10].

Nonoperative treatment can yield excellent outcomes in around 80% of proximal humeral fractures. Nonsurgical alternatives prioritize the implementation of early functional exercises in order to attain a range of motion that is deemed functionally satisfactory. There is currently no universally accepted standard of care for the surgical management of displaced proximal humerus fractures, which account for around 15% to 20% of cases. Nevertheless, a range of internal fixation techniques, including as the utilization of k wires and screws, blade plates, external fixators, T-plates, intramedullary devices, locking compression plates, and shoulder arthroplasty, have been documented in the literature. However, it is worth noting that none of these procedures have demonstrated consistent success. In order to achieve complete functional recovery, it is necessary to prioritize anatomical reduction, stable fixation, and early mobilization [11, 13].

The blood supply to the head of the humerus is susceptible to potential compromise, not only due to injury but also as a result of soft tissue dissection during open reduction and fixation procedures. Studies have revealed the occurrence rates of malunion, nonunion, and avascular necrosis subsequent to open reduction and internal fixation (ORIF). The risk of developing avascular necrosis (AVN) is heightened with prolonged exposure and the use of implants. Conversely, it is advised to minimize exposure and dissection of the soft tissues near the fracture site, while employing minimal internal fixation. Achieving stable reduction is a crucial aspect in the healing process of a fracture, as it facilitates early mobilization of the shoulder joint [12, 14].

Given the aforementioned criteria, fractures of this nature were managed using several methods including the utilization of screws, AO T-plates, locking compression plates, or osseous suturing. The objective of this study was to analyze a cohort of patients who experienced fractures in the proximal region of the humerus, which is a common injury in this population. The patients were treated using rigid internal fixation after achieving a near anatomic reduction. The study focused on evaluating the functional outcomes, range of motion, strength, and complications associated with this treatment approach [13, 15].

Materials and Methods

The present investigation was carried out in the Department of Orthopaedics, Andhra Medical College, Vishakhapatnam, Andhra Pradesh, India. This study is a prospective investigation conducted between January 2021 to December 2022, using a sample size of 20 cases. In this study, proper informed permission was gained from every patient involved, ensuring that they were fully aware of the nature and purpose of the research and voluntarily agreed to participate.

Inclusion Criteria

- Fractures of the proximal third misplaced humerus that require internal fixation.
- Patients who agree to participate in the research.
- Individuals who exhibit skeletal maturity.

Exclusion Criteria

- Pathological fractures.
- Undisplaced fractures.
- Skeletal immaturity with open physis.
- Medically unfit for surgery.
- Lack of willingness for surgery.

Methods

The study collected information on demographic characteristics, the cause and nature of the injury, the extent of the damage, any further injuries, and the initial therapy provided, and the duration until definitive treatment was administered. The study documented intra-operative events and challenges, as well as post-operative complications at the local or systemic level. Additionally, the time taken for bone union and the duration required to resume pre-injury activities were recorded. During the final assessment, all patients underwent radiological and functional evaluation utilizing the constant score. In the present study, the sample comprised 20 participants, consisting of 5 females and 15 males. The age range of the participants in the study spanned from 19 to 83 years, with a median age of 42 years. The majority of patients in the study population were involved in road traffic accidents (RTAs), with the exception of one individual who experienced a fracture as a result of a fall. The maximum duration of follow-up seen in the study was 26 months, while the average duration of follow-up was found to be 14 months. All participants included in our study exhibited right-handedness. Specifically, out of the total

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sample, 12 patients presented with a fracture of the right proximal humerus, whereas 8 patients exhibited a fracture of the left proximal humerus. The prevalence of road traffic accidents can be ascribed to the practice of left side driving on the roadways.

Results

Ten patients received locking compression plates, six received AO T buttress plates, three received screws only, and one received k wires only during 20 surgical procedures. Among the cohort of 20 patients under observation, it was found that 5 patients exhibited exceptional scores, 4 patients demonstrated acceptable scores, 10 patients displayed moderate scores, and 1 patient exhibited bad outcome scores. The average constant score is 72.19. The mean constant score for Neer two-part fractures was found to be 76.21, whereas Neer three-part fractures had a mean constant score of 72.19. Additionally, Neer four-part fractures exhibited a lower mean constant score of 58.83.

Table 1: Repositioning in anatomical proper manner

Number of Fragments	Number of Patients	Score (Constant)
2	10	72.19
3	6	76.21
4	4	66.35

All 20 patients achieved union within approximately six weeks of follow-up, except for the cases that were complicated by screw pull-out and fixation failure.

Table 2: Stiffness

Fragments (Number)	Patients (Number)	Percent
2	6	30
3	12	60
4	2	10

Complications: The prevailing consequences following surgical intervention for proximal humerus fractures encompass stiffness, prolonged pain, postoperative infection, fixation failure, osteonecrosis, and delayed rotator cuff rupture. A patient diagnosed with a Neer 4-part fracture exhibited accompanying axillary vein damage, necessitating immediate surgical intervention for correction. Two individuals, each diagnosed with Neer 3 component fractures, subsequently exhibited osteonecrosis of the humeral head. The overall proportion was 8%.

A single patient diagnosed with a Neer 3-part fracture had treatment using a locking compression plate. However, on the 13th day after the operation, the implant experienced a failure, with the screws dislodging from the humeral head. As a result, a revision surgery was performed. However, over time, the patient developed osteonecrosis of the humeral head, resulting in a significantly low constant score of -33. The occurrence of postoperative infection is an inherent possibility that necessitates constant consideration. In order to prevent rigidity, it is imperative that the fixation is sufficiently robust to permit prompt passive movement, hence minimizing adhesive scarring and facilitating functional recovery. The diagnostic assessment may reveal that the infection is classified as either acute or chronic. In cases of acute infection, it may be deemed appropriate to retain the implants if they serve to enhance stability.

Two patients experienced deep infections, with one patient exhibiting symptom on the 5th day after surgery and the other patient on the 12th day post-operation. In response, wound irrigation was performed and broad-spectrum antibiotics were administered following pus culture and sensitivity testing. Both patients experienced resolution of their infections, with a moderate score observed during their most recent follow-up assessments. Avascular necrosis does not inherently present as a clinical issue. Nevertheless, there is a possibility that it could result in either partial or complete collapse of the humeral head, leading to incongruity. The potential outcome of this situation could lead to operational failure and discomfort, despite the fact that the visual representation on an x-ray often does not align with the observed symptoms. The occurrence of osteonecrosis is inevitable; however, it is imperative to employ a thorough surgical method that prioritizes the preservation of the blood supply to all fragments.

Table 3: Difficulties

Complications	Number of patients
Inability to secure or unscrew	2
humeral head primary screw perforation	1
Axillary nerve impairment	0
infection of wounds	3
Non-union or delayed union	0

Discussion

Treatment of three- or four-part humeral fractures is a substantial therapeutic challenge. The surgeon

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must ensure accurate anatomical alignment and reliable fixation, all while protecting the humeral head's blood supply as much as possible to prevent avascular necrosis [16]. The existing body of literature generally believes that anatomical reduction of the fracture and a firm fixation, regardless of the precise surgery and implant chosen, are two critical variables necessary for attaining a satisfactory functional outcome following a shoulder fracture. In addition, it is essential to start functional rehabilitation for the shoulder as soon as possible for best outcomes. The use of stiff internal fixation for the surgical treatment of proximal humeral fractures has increased in recent years. These implants were designed to reduce the risk of future reduction loss, especially in elderly individuals with osteoporotic bone [17, 18], despite the availability of rapid and dependable functional postoperative treatment.

The standard plate osteosynthesis treatment showed dismal outcomes in the older population affected with osteoporosis. For better and more consistent results, the AO/ASIF has designed a unique locking compression plate for proximal humerus fractures. Standard plate osteosynthesis has been shown in previous research to have positive clinical effects in patients with good bone quality [19]. Esser achieved remarkable results in the evaluation of a cloverleaf plate, earning an ASES score of 84.6%. In a 2006 prospective research, using cloverleaf plates was associated with a 72.4-point average Constant. In addition, it was discovered that 59% of treated patients had good or very good results [20]. Paavolainen *et al*. (year) looked at the results of 41 people who had been diagnosed with severe proximal humerus fractures, and found that 74.2% of them had good outcomes. Plate and screw devices were used in the patients' treatments. Using the Neer score and a clink plate, Kohler *et al*. (year) showed successful outcomes in 95% of cases. Similarly positive effects have been observed while employing simply Kirschner wires. A Constant-Murley score of 77.1 was recorded by Zingg *et al*. (year), whereas a score of 88.2 was reported by Jiang *et al*. Wachtl *et al*. used Prevot nails in their investigation, and found that the average Constant-Murley score improved by 63 points throughout the course of the follow-up. The average Constant-Murley score of 63.44 points indicates a successful clinical result in this study [20, 23].

Internal stabilization of proximal humerus fractures has similar short-term outcomes when compared to external fixation, according to a meta-analysis. Previous research has shown that the initial level of functioning is similar to the ultimate long-term outcome, so our study's short follow-up period shouldn't be too much of a concern. The severity of the fracture, the bone's anatomical alignment, the injury's etiology, the bone's quality, the time elapsed between the injury and surgery, the presence of any additional injuries, and the accuracy with which the implant is placed and stabilized all appear to have a bearing on the outcome [24, 26].

Accomplishing a precise anatomical reduction and placing the plates in the right spots led to a dramatically better clinical outcome. In situations where anatomical reconstruction was unsuccessful or a nonanatomical reconstruction was adopted intraoperatively, the Constant-Murley score decreased significantly. Subacromial impingement can occur if the plate is not properly positioned on the shaft at the correct height. This significantly lowers the Constant-Murley score. Six patients with adverse outcomes were included in the analysis. Two patients reported with humeral head osteonecrosis, one patient presented with persistent dislocation following surgery, one patient experienced screw pull out from the humeral head, and two patients presented with chronic shoulder discomfort [27, 29]. Similar to the 2.5% infection rate reported by Paavolainen *et al*. in their patient cohort, we found a similar 8% infection rate in our study. Patients who developed aseptic necrosis of the humeral head had a much worse clinical prognosis, with a mean Constant-Murley score of 25.50. Necrosis rates for 3- and 4-part fractures described in the available literature range from zero percent to fifty percent, depending on the osteosynthesis method used. Our findings on the rate of aseptic necrosis are consistent with the lower end of the range reported elsewhere [30, 33].

It is possible that the low prevalence of avascular necrosis [34] is due to a combination of factors, including the high level of primary stability. Improvements in functional outcomes were observed to be significantly linked with the use of firm internal fixation and precise anatomical realignment of the tuberosities. Our results show how crucial it is to properly realign patient fragments back into their original anatomical positions. Plate and screw fixation for three- and four-part fractures were shown to provide better functional outcomes than conservative treatment or semi-rigid fixation procedures that did not require anatomical realignment of the head fragment, according to the study. With increased muscular strength and functionality, shoulder function continued to improve [35, 37].

Conclusion

Despite the relatively short follow-up duration and the absence of randomization in our study design, the findings demonstrate comparability with previously published studies. The achievement of a satisfactory final functional outcome seems to be mostly contingent on achieving precise anatomical reduction, rather than the specific implant utilized. This aspect remains unaffected by the chosen implant type and method. The selection of the surgical approach and implant type is contingent upon several factors, including the fracture pattern, bone quality, patient objectives, and the surgeon's proficiency with various approaches. The learning curve associated with the use of implants is undoubtedly a contributing factor. The implementation of a proficient surgical approach will effectively mitigate difficulties, while the

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implementation of a rigorous rehabilitation regimen will optimize the outcome. Typically, fractures that involve two or three parts can be managed through the utilization of open reduction and internal fixation techniques. Open reduction and internal fixation have been shown to be effective in the successful treatment of four-part fractures in younger, physically active patients.

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Conflict of Interest
None

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