



Department of Orthopedic and Trauma Surgery

**EFFECTS OF DELAYED SURGICAL INTERVENTION, DELAYED
PHYSIOTHERAPY AND IMPLANT CHOICE ON FUNCTIONAL
OUTCOME OF BI-COLUMNAR FIXATION TECHNIQUE FOR DISTAL
HUMERUS FRACTURES IN AABET HOSPITAL ADDIS ABEBA
ETHIOPIA**

**By: Dr. Ayalew Komande M.D (Orthopedic & Traumatology Surgery
Resident)**

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Addis Ababa, Ethiopia

EFFECTS OF DELAYED SURGICAL INTERVENTION, DELAYED
PHYSIOTHERAPY AND IMPLANT CHOICE ON FUNCTIONAL OUTCOME
OF BI-COLUMNAR FIXATION TECHNIQUE FOR DISTAL HUMERUS
FRACTURES AT AABET HOSPITAL FROM JANUARY/2016 TO
DECEMBER/2021

BY: DR. AYALEW KOMANDE M.D (Orthopedic & Traumatology Surgery
Resident).

PUBLIC HEALTH ADVISOR; MR, EYOEL BIRHANE (MPH).

CLINICAL ADVISOR: DR. ADDISU DERIBE (MD, Assistant Professor of
Orthopaedics and Traumatology).

A RESEARCH THESIS TO BE SUBMITTED TO THE DEPARTMENT OF
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Investigator	Ayalew Komande (MD, Orthopedics and Traumatology Resident).
The full title of the research project	Effect of delayed surgical intervention, delayed physiotherapy and implant choice on Functional Outcome of bicolunar fixation for Distal humerus fractures at AaBET Hospital from January 2016 to December 2021
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Source(s) of Funding	SPHMMC
Address of investigator	Tel:
	Cell phone: +251911865948
	Fax:
	P.O. Box:
	Email: ayalewkomande92@gmail.com
Name of Advisor(s)	1. Eyoel Birhane, MPH, Department of public health 2. Addisu Deribe, (MD, Assistant Professor, Consultant in Orthopedics and Traumatology)

Summary

Background: Distal Humerus fractures are complex injuries with limited options for internal fixation due to their multi-fragmented nature and osteopenic bone. Bicolumnar plating is a stable form of internal fixation that allows for the early mobilization of the joint. Despite global research on distal Humerus fractures, there is a lack of studies on functional outcomes in our country. Thus, this study can serve as a valuable guide for further research and development of guidelines.

Objective: To assess effects of delayed surgery, delayed physiotherapy and implant choice on functional outcome in patients with distal humerus fractures treated with bi-columnar fixation.

Methods: A health facility-based cross-sectional study design conducted among patients with distal humerus fractures treated with bi-columnar fixation at AABET hospital. Data were collected by reviewing existing medical records and objectively evaluating the patients. The study was conducted on a sample size of 52 and Purposive sampling technique was used. Descriptive statistics such as frequency and percentage were used to summarize the results. Multivariable ordinal logistic regression and one-way ANOVA, were used for the analysis. P-value < 0.05 was considered statistically significant.

Results: This study constituted 39(75%) males and 13(25%) females. The magnitude of excellent and good clinical outcomes was 61.5% and the mean elbow functional outcome was 75.8 ± 9.8 . Delay in surgery $1.74(1.31, 2.313)$, had significant effects on the functional outcome ($p < 0.05$). Delay in early physiotherapy, and use of non-rigid plates like one-third tubular plates had significant difference on the functional outcome ($p < 0.05$).

Conclusion:

The mean MEP score of this study 75.8 ± 9.8 is worse than most other studies. Delay in surgery, was associated with worse clinical outcomes. use of non-locking plates, and delay in physiotherapy had a significant difference on functional outcome compared to use of locking plates and early physiotherapy in the bi-columnar fixation of distal humerus fractures respectively.

Key Words; Distal humerus fracture, bi-columnar fixation

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Contents

ABSTRACT.....	Error! Bookmark not defined.
Acknowledgment	Error! Bookmark not defined.
Acronyms & Abbreviations	Error! Bookmark not defined.
LIST of TABLES.....	VII
LIST of FIGURES	1
1. Introduction.....	Error! Bookmark not defined.
1.1 Background	Error! Bookmark not defined.
1.2 Statement of the Problem	Error! Bookmark not defined.
1.3 Significance of Study	4
2. Literature Review.....	5
3.1 General Objectives	Error! Bookmark not defined.
3.2 Specific Objectives.....	Error! Bookmark not defined.
4 Methodology	Error! Bookmark not defined.
4.1 Study Area.....	Error! Bookmark not defined.
4.2 Study Period	Error! Bookmark not defined.
4.3 Study Design	Error! Bookmark not defined.
4.4 Source Population & Study Populations	Error! Bookmark not defined.
4.5 Sample Size Determination and sampling procedures	Error! Bookmark not defined.
4.6 Inclusion Criteria.....	Error! Bookmark not defined.
4.7 Exclusion Criteria.....	Error! Bookmark not defined.
4.8. Study variables	Error! Bookmark not defined.
4.9. Data Collection and Quality Assurance:	Error! Bookmark not defined.
4.10. Data Analysis	Error! Bookmark not defined.

4.11. Operational Definition.....	Error! Bookmark not defined.
4.12. Ethical Consideration	Error! Bookmark not defined.
4.13. Dissemination of Results.....	Error! Bookmark not defined.
5. Result	Error! Bookmark not defined.
5.1 Socio-Demographic characteristics of the study population	Error! Bookmark not defined.
5.2 Variables related to fracture character.....	16
5.3 Variables Related to Complications and rehabilitation.....	18
5.5 Univariate ordinal logistic regression,analysis of variables having significant effect on functional outcome.....	20
5.6 Multivariable ordinal logistic regression, one-way ANOVA, and used for the analysis of factor that have significant effect on clinical outcome.	Error! Bookmark not defined.
5.7 one-way ANOVA analysis of factors associated with functional Outcome	Error! Bookmark not defined.
6. Discussion	23
7. Limitations of study	Error! Bookmark not defined.
8. Conclusion	Error! Bookmark not defined.
9. Recommendation	Error! Bookmark not defined.
10. References.....	Error! Bookmark not defined.
11. Annexes.....	Error! Bookmark not defined.

Acronyms and Abbreviations

AaBET	Addis Ababa Burn, Emergency and Trauma Hospital
AO	Arbeitsgemeinschaft für Osteosynthesefragen
EMCC	Emergency Medicine and Critical Care
FMOH	Federal Ministry of Health
HO	Heterotrophic ossification
MEPS	Mayo Elbow Performance Score
MEPI	Mayo Elbow Performance Index
OO	Olecranon Osteotomy
ORIF	Open reduction and internal fixation
OTA	Orthopedic Trauma Association
PTOA	posterior triceps on approach
ROM	Range of motion
RTA	Road traffic accident
SPHMMC	St. Paul's Hospital Millennium Medical College
SPSS	Statistical Package for Social Science
VAS	Visual analog scale
WHO	World Health Organization

LIST of TABLES

Table 1: Overview of MEPS Criteria	14
Table 2: Socio-Demographic characteristics of the study patients, AABET hospital, 2023.....	15
Table 3: Frequency distribution of variables associated with fracture character, AABET hospital, 2023.....	16
Table 4: Comparing variables with their mean meps, AABET hospital, 2023.....	19
Table 5: Postoperative complications, AABET hospital, 2023.....	20
Table 6: Clinical outcome frequency distribution.....	20
Table;7: Univariate ordinal logistic regression analysis of factors having significant functional outcome.....	21
Table 8: Multivariable ordinal logistic regression for factor that have significant effect on clinical outcome, 2023.....	21
Table 9: One Way ANOVA analysis of Factors associated with Clinical Outcome, AABET hospital, 2023.....	22

LIST of FIGURES

Figure 1: Percent Distribution of patients according to age.....16

Figure 2: Distribution of patients according to time to surgical intervention.... 18

Figure 3: Distribution of patients according to type implant used for fixation..... 18

Figure 4: Distribution of patients according to time of start of rehabilitation..... 19

1. INTRODUCTION

1.1Background

A distal Humerus is defined as the square of the epicenter between the epicondyles as described by Mueller (1). As the shaft approaches the distal humerus it bifurcates into two divergent cortical columns, termed the medial and lateral columns (2). These columns of bone support the distal humeral articular surface in an inverted-Y configuration (8).

The Orthopedic Trauma Association's alpha-numeric system, assigned three main types: Type A is extra-articular, Type B is partial articular, and Type C is complete articular both columns, no part of the joint is continuous with the shaft. This system is widely used in the literature and trauma databases (1). Currently, fracture of the distal humerus is more commonly described based on the columnar structure of the distal humerus. This includes describing fractures as single columnar involving either the medial or lateral column, bi-columnar involving both the medial and lateral column and trans-columnar fractures (5). They are commonly multi-fragmented, occur in osteopenic bone, have complex anatomy with limited options for internal fixation and follow a bimodal age distribution (1). In young adults, the fractures are typically caused by high-energy injuries, such as motor vehicular collisions, falls from height, sports, industrial accidents, and firearms and most of these are intra-articular and involve both the medial and lateral columns. In contrast, greater than 60% of distal Humerus fractures in the elderly occur from low-energy injuries, such as a fall from a standing height (1).

Distal Humerus fractures remain some of the most challenging injuries to manage as the majority of these fractures (96%) have a complex pattern like severe comminution, having bone fragment loss, comminution in an osteoporotic bone that involves both the columns and the articular surface (4). In the past, many treatment methods were used for distal Humerus fractures including non-operative treatment and percutaneous methods using Kirschner wires that needed prolonged periods of the cast, increasing the risk of local complications such as joint stiffness, mal-union, and non-union. In the elbow, the principles of good anatomical alignment, absolute stabilization, and early mobilization are of prime importance than in any other joint. For this reason, the risk of functional impairment is relatively high when these injuries are managed nonoperatively (1). The indication for non-operative treatment of distal Humerus fractures is limited and primarily involves patients with very low demand or in poor health.

The majority of current recommendations in the management of distal humeral fractures include open reduction and internal fixation (ORIF) with plates and screws. Single-column plating (applying a plate over one column) for some partial, articular fractures does not provide a stable construct for most distal humerus fractures as compared to the double-column plating methods. [7,8]. Single columnar plating has more fixation failure (12). ORIF with Dual plating of the fracture allows the surgeon to restore the anatomical alignment of the fracture fragments and permit early range of motion (ROM) exercises which may aid in the return of a functional ROM of the elbow postoperatively and is considered as the gold standard mode of treatment (6). Presently this dual fixation provides the most acceptable outcome.

The best way to expose both columns of the distal Humerus and the articular surface is through a posterior approach (9), which involves a longitudinal skin incision and elevation of full-thickness medial and lateral flaps (1). There are several posterior approaches, classified into three main types: olecranon osteotomy, paratricipital (triceps-on), and triceps-off approaches. The olecranon osteotomy approach which involves olecranon osteotomy made in a shallow 'V' or Chevron fashion approximately 2cm from the tip of the olecranon (10), provides the best visualization of the distal Humerus articular surface. The paratricipital (triceps-on) approach has limitations in visualization, while the triceps-splitting approach can be challenging to visualize the articular surface.

Double-column plating technique is either orthogonal or perpendicular where one plate is placed in the medial column and another plate is placed in a posterolateral column or parallel configuration with the placement of plates on both medial and lateral columns. [11]. Even though controversies exist, there is no significant difference in functional outcomes between these two techniques (11).

Early surgery within 48 to 72 hours is associated with good outcomes. Although a suitable delay for the distal humerus is not clearly defined, surgery should be conducted within 2 or 3 weeks (1). Delay beyond this time would result in, difficult reduction and open reduction and internal fixation (ORIF), increased risk of complications (1).

poor outcomes could occur in bicolumnar fixation, often resulting after prolonged immobilization that prevents early range of motion, when rigid internal fixation cannot be achieved but, irrespective of the treatment method chosen, any substantial damage to the distal humerus usually results in limitation of motion, pain and possibly instability. (8)

Other complications associated with potentially poor outcomes include malunion, nonunion, contracture, avascular necrosis, Heterotrophic ossification (HO), hardware failure, and symptomatic prominent hardware (1).

Applying bi-columnar locking compression plates, detailed preoperative evaluation, careful management of the soft tissues, adequate visualization of the fracture, proper fixation technique, and early postoperative mobilization has good functional outcome (12). Although good or excellent outcomes have been reported by various studies, comparison between them is difficult owing to the variation in fracture classification, operative techniques, and outcome measures used, and most studies are reported with a considerable number of cases.

1.2 Statement of the Problem

Distal humerus fractures, account for 0.5–7% of all fractures and represent approximately 30% of fractures about the elbow (4). Due to rapid industrialization and the growth of the automobile industry, there is an increase in road traffic accidents. In a study conducted by Palvanen, elderly aged (> 60 years) were predicted to have a three-times increase in incidence by 2030(11). High-energy injuries are the causes of most intra-articular distal humerus fractures in young adults

The elbow is one of the most restrained joints of the body and tolerates immobilization poorly, and contributes the highest functional movement of the upper extremity. Therefore, distal humerus fractures especially intra-articular which have an alteration within the architecture of the joint have the potential to limit motion and compromise elbows function (15).

Treatment of fractures of the distal humerus is predominantly surgical with nonsurgical management reserved for patients whose medical problems preclude safe surgical intervention, as nonsurgical management is associated with worse clinical outcomes (12). Recovering a painless and functional elbow after distal humerus fracture requires, anatomic reconstruction of the articular surface, restoration of the overall shape of the distal humerus, and creating a fixation construct that is rigid enough to tolerate early mobilization. So, fixing only Single columns, and plating with either reconstruction or conventional plates have more fixation failures as achieving stable fixation will be difficult (10). Internal fixation with the bi-columnar (with either parallel or

perpendicular plating) method reconstitutes the congruity of the elbow and allows stable fixation with early and full rehabilitation (4) of the joint and provides the most acceptable outcome (6).

Regarding implant choice, pre-contoured locking plates have demonstrated superior biomechanical properties compared with one-third of tubular plates, and reconstruction plates, but the literature on clinical outcomes after treatment with pre-contoured locking plates is limited (14).

Despite recent advances in surgical techniques, functional deficits can be significant and impose a challenge to even experienced surgeons as it is complicated by the anatomy of the elbow, small area of fixation, associated comminution, and osteopenia of articular surfaces (13). Despite all efforts made, the degree of fracture comminution by itself affects the outcome as complex fractures of the distal humerus are difficult to treat and functional outcomes worsen when the fracture type becomes more complex (12).

Various studies are reporting functional outcomes of open reduction and internal fixation of distal humerus fractures with bi-columnar fixation (15), some studies found a substantial failure rate of up to 25% especially in elderly patients (14).

Although comparison of these studies is difficult as most of them used small sample sizes, varying fracture patterns, different surgical techniques, and rehabilitation, most of the studies have found a good or excellent outcome.

Even though there many studies are available elsewhere, there is no study on the functional outcome of distal humerus fracture treated with bi-columnar fixation in our country.

In our setup, there is uncertainty regarding the expected outcomes, as there is no adherence to the standard principles for implant placement, timing of physiotherapy and timing of surgery,. Hence, this study will serve as a baseline study and helps to put forward solutions.

Therefore, this study is aimed at determining the functional outcome and to determine choice of implant placement, timing of physiotherapy and timing of surgery and their effects on functional outcomes of distal humerus fractures among patients treated with open reduction and internal fixation with a bi-columnar method for distal humerus fracture and on follow-up at AaBET Hospital in the orthopedics surgical clinic.

1.3 Significance of the Study

Though uncommon, 2-6% of all fractures, distal Humerus fractures account for 30% of all elbow fractures. Difficulty in achieving the goal of good fracture reduction and fixation is due to complex joint anatomy, forces acting across the elbow, osteoporosis, and decreased primary stability. This can result in up to 35% of complications and poor results. Although most studies have found good functional outcomes, interpretation of the available literature dedicated to the outcome of distal humeral fractures is often difficult because the studies often are only a small case series, compare heterogeneous fracture patterns, compare inconsistent fixation, rehabilitation techniques, and functional outcomes (15).

Although we have been using this type of fixation for years in our setup for the treatment of patients with distal humerus fractures, there is no single study done in the setup comparing the functional outcome of patients treated with bicolunar fixation. So, this study will provide a comprehensive report on the functional outcome of this management option. In addition to that, it also gives a generalized prevalence of distal humerus fracture plus operative details on bicolunar fixation on these fractures. To identify factors that have led to worse clinical outcomes and help as baseline information to take measures to prevent those factors in the future. This research will also help the AaBET hospital and other concerned bodies by providing necessary information to improve the health care facility management options. Concomitantly, it will be used as baseline information for researchers which will be conducted on this area in the future.

2. Literature review

Distal humerus fractures remain some of the most challenging injuries to manage. They are commonly multi-fragmented, occur in osteopenic bone, and have complex anatomy with limited options for internal fixation. Treatment outcomes are often associated with elbow stiffness, weakness, and pain (24).

Distal humerus fractures occur in a bimodal distribution, peaking early in young patients with high-energy trauma. A study at Vydehi Institute of Medical Sciences and Research Centre in Bengaluru found that 30 patients with distal humerus fractures had an average age of 37.5 years. 50% of patients were aged 18-35 years, with 19 males and 11 females. 13 patients had right-side injuries, and 17 had left-side injuries, with road traffic accidents being the primary cause (2).

In 1811, Desault was the first to state that these fractures are the most difficult of all fractures, with treatment options, ranging from essentially no treatment to replacement of joints.

In the early 20th century, many authors were in favor of a conservative approach. But, the results of conservative management were, poor (6). In the last quarter century, improved outcomes have been reported with surgery for distal humerus fractures. In the last decade, there have been advances in the understanding of elbow anatomy, improvements in surgical approaches, new fixation devices, and an evolution of, and an evolution of postoperative rehabilitation protocols (1). Currently, conservative treatment remains appropriate only for very low-demand patients and those unable to undergo surgery.

The main goal of surgical treatment is to obtain fixation that is stable enough to allow immediate post-operative elbow mobilization and prevent it from stiffening, hence open reduction and internal fixation allow early mobilization and good functional outcomes (12).

A study of 18 patients with intercondylar fractures of the distal humerus found that 83.33% had excellent or good outcomes after open reduction and bi-columnar fixation using pre-contoured anatomical plates and screws. Physiotherapy was started within 10 days of surgery, and outcomes were evaluated between 12- and 20 months post-surgery. Flexion was significantly impaired in C3 fractures. All AO C1/C2 fractures had excellent or good outcomes, but only 75% of C3 fractures had excellent or good outcomes. (19).

Single columnar plating, conventional plates, and Recon plating are associated with more fixation failures, while the use of two pre-contoured anatomical locking compression plates is considered the most acceptable technique for distal humerus fracture (12). A study conducted at Oslo University Hospital involving 57 patients aimed to evaluate the outcomes of operative treatment for distal humeral fractures using pre-contoured locking plates. The study concluded that despite the cohort being divided into two groups based on age, patients aged 65 years or older did not show worse outcomes compared to younger patients. Moreover, the study found no significant differences in functional outcomes, patient-reported outcomes or complication rates between the age groups. The text suggests that ORIF with pre-contoured locking plates is an effective treatment method for distal humeral fractures in adults, regardless of age (14).

The choice of a surgical approach depends on multiple factors, including, fracture pattern, extent of articular involvement, associated soft tissue injury, and surgeon's preference. A study was conducted on 35 patients with intercondylar AO Type C fractures in Secunderabad, India

between 2015-2016. The choice of a surgical approach based on fracture pattern, articular involvement, soft tissue injury, and surgeon's preference revealed no significant difference in functional outcomes. The majority of surgeries used olecranon osteotomy with parallel plating. All of the fractures were fixed with a locking plate. On 2nd post-op day, gentle elbow ROM exercises (passive and active assisted) started under the direct supervision of the operating surgeon and then physiotherapy followed. The MEPS scoring system showed excellent outcomes in 42.86% and good outcomes in 37.14% of patients (4).

The Department of Orthopedics at Govt. Medical College in Patiala, India conducted a study evaluating the functional outcomes of treating closed intra-articular fractures of the distal humerus in 30 adults. Patients with certain types of fractures and neglected injuries were excluded. The patients were randomly divided into two groups and treated using either parallel plates or orthogonal plates. Their elbow function was assessed using MEPS, and they were followed up for six months. The study found that in group 1, the mean MEPS was 85.6 points, while in group 2, it was 88.3 points. However, complications were observed in 44% of patients, including painful hardware, superficial infection, and transient ulnar nerve palsy. The study concluded that both parallel and orthogonal positioning can provide adequate stability and anatomical reconstruction of distal humerus fractures when applied appropriately with suitable plates (2).

A study was conducted from May 2019 to December 2021 at Rajah Muthaiah Medical College and Hospital to evaluate post-traumatic intra-articular distal humerus fractures treated with bi-columnar fixation. 20 patients underwent the procedure, with the Mayo Elbow Performance Score (MEPS) used to assess their functional outcomes. The study concluded that the Olecranon Osteotomy approach provided better visualization and an easier opportunity for articular reconstruction (2).

For AO/OTA type C fractures, olecranon osteotomies are frequently utilized because they offer superior visualization of the articular surface. However, this approach also carries potential risks such as nonunion, malunion, and hardware irritation (1).

Controversy exists regarding the best treatment option for elderly patients. Osteosynthesis becomes more technically demanding and the outcome is less predictable due to the presence of osteoporosis, comminution, and poor soft-tissue conditions (22).

A recent study conducted in Austria analyzed the efficacy of ORIF treatment for elderly patients suffering from distal humerus fractures. The study reviewed 27 patients over the age of 70 between 2004 and 2012 and found that 85% of them had positive outcomes. The study concluded that ORIF treatment can be effective for elderly patients, and age should not be considered a contraindication for this type of treatment (23).

A study in India found that bi-columnar plating is a good treatment for elderly patients with comminuted intra-articular distal humerus fractures. Patients who had surgery within a week of trauma and were followed for at least two years had a mean MEP score of 85. All elbows were stable, and there were minimal complications and revision rates. The study suggests that this treatment offers good functional outcomes for elderly patients. (15).

The trauma and orthopedics department at the Hubert Koutoukou MAGA National Teaching Hospital in Cotonou, Benin conducted a retrospective study from 2001 to 2015 on 38 patients with distal humerus fractures. The patients' mean age was 33.6 years (ranging from 16 to 71). The study found that 81.6% of the injuries were caused by road traffic accidents, while 10.5% were due to domestic accidents. Type C fractures were the most common (68.4%), while type B fractures were the least common (5.3%). The average time to surgery was 21 days (ranging from 1 to 55 days). The approach used was posterior trans-Olecranon in 65.8% of cases and trans-tricipital in 5.3%. The study utilized the Lecestre plate as an osteosynthesis material in 76.3% of cases. The Lecestre plate is an anatomically pre-contoured, low-profile plate used for both intra-articular and extra-articular distal humerus to fit the medial and lateral epicondyle of the distal humerus. The Lecestre plate+1/3 tubular plates were used in 55.3% of cases and Lecestre plate screwing in 7% of cases. The study found that the mean MEPS score was 66.3 points (ranging from 100 to 45 points) with excellent results in 21.1% of cases, good results in 34.2% of cases, average results in 26.3% of cases, and bad results in 18.4% of cases. The study concluded that solid osteosynthesis allowing early physiotherapy is the best approach for optimal recovery of elbow function. (24).

Both column fixation requires more dissection and exposure, so there is a high incidence of implant-related complications like elbow stiffness and nerve injury (29).

a study by Asfuroğlu et al. found that 7.7% wound site infection and 7.7% nerve related complications. After they operated all AO1 on 3C fractures with olecranon osteotomy with a

mean duration of 3.8 days (range, 1–16 days) prior to surgery. Excellent and good outcomes were obtained in 48.7% (n=19) of the patients (21).

Several retrospective series have highlighted the importance of early mobilization within 14 days for satisfactory functional outcome outcomes

3. Objectives

3.1 General Objective

- To Assess the effects of delayed surgery, delayed physiotherapy and implant choice on functional outcome of patients with distal Humerus fractures treated with bi-columnar fixation at AaBET Hospital, Addis Ababa, Ethiopia, 1/1/2016-30/12/2020G.C.

3.2 Specific Objective.

- To determine functional outcomes of distal humerus fractures treated with bicolumnar fixation at AaBET Hospital, Addis Ababa, Ethiopia, 1/1/2016-30/12/2021G.C.
- To determine effect of delayed surgery, delayed physiotherapy and implant choice on functional outcomes of distal humerus fractures treated with bicolumnar fixation at AaBET Hospital, Addis Ababa, Ethiopia, 1/1/2016-30/12/2021G.C.

4. Methods and materials

4.1. Study area description

This study was conducted at AaBET Hospital, St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia. SPHMMC is located in Swaziland Street, Wereda 09, Addis Ketema S/City, Addis Ababa, Ethiopia. SPHMMC was built in 1969 by Emperor Haile Selassie I with the help of the German Evangelical Church with the main aim of serving the under-served. It is one of the leading public hospitals and medical colleges in the country. It has a catchment population of more than 5 million, mainly acting as a referral center. It was renamed as SPHMMC in 2007 G.C, when medical school was opened under it. It has over 13 departments, over 700 inpatient beds and has the responsibility of rendering patient care, training for medical

& health science undergraduate and postgraduate students and carrying out research. In 2015, AaBET was inaugurated as a public hospital under SPHMMC, located in Dejazmach Zewdu Aba Koran Street/Arada Sub-city/Addis Ababa/Ethiopia, and it is one of the first health sectors with an entire trauma and burn unit. The hospital has more than 200 beds and around 800 staff. It includes departments in EMCC, Neurosurgery, and Orthopedics and Traumatology, and Plastic and Reconstructive Surgery.

The reason AaBET Hospital, SPHMMC is chosen for the study is, its recognized as one of the biggest governmental based trauma and emergency center of the country and have a large orthopedic surgery and traumatology department which stuffed with large number of specialists and subspecialists and give treatment for numerous patients.

4.2 Study Period

A six-year retrospective study, from January 1/2016 to December 31/2021, was conducted in the department of orthopedic and Trauma surgery, AaBET hospital, SPHMMC, starting from February/2023 to May 30/2023.

4.3 Study Design

The study design was a hospital based cross-sectional study on patients with distal Humerus fracture treated with bi-columnar fixation during the period between January 01/2016 to December 1/2021, in AaBET hospital, SPHMMC, Addis Ababa, Ethiopia. The study participant patients were identified using the hospital logbook. The patients' functional outcome was assessed by Mayo Elbow Performance Score (MEPS) which was filled by a treating physician or investigator asking the patient coming for follow-up. Patients who could not come to the clinic were interviewed by phone and reviewed by a local physician.

4.4. Population

4.4.1 Reference Population

All cases of distal humerus fracture who were treated with open reduction and internal fixation at AaBET hospital, SPHMMC.

4.4.2 Study Population

All cases of distal humerus fracture treated with bi-columnar fixation, in the department of orthopedic surgery and traumatology, AaBET hospital, SPHMMC, Addis Ababa, Ethiopia, during the study period, from January 01/2016 to December 31/2021 and has follow up ≥ 1 year

4.5 Eligibility Criteria

4.5.1 Inclusion Criteria:

- All cases of distal humerus fracture treated with bi-columnar fixation during the study period and had at least 1 year postoperative follow up

4.5.1 Exclusion Criteria:

- All cases of distal humerus fracture treated with bi-columnar fixation during the study period for pathological fractures
- Revision surgeries
- Fracture delayed more than 3 weeks

4.6 Sample Size and Sampling technique

4.6.1 Sample Size

All patients with distal humerus fracture treated with bi-columnar fixation, who are not excluded by the exclusion criteria, in the study period will be taken as subjects of the study a total of 52 patients are included in the study.

4.6.2 Sampling method

There were 64 patients operated for distal humerus fractures treated with bicolunar fixation. Since small number of study population from AaBET Major OR Log Book data recovered, the study aims to include all eligible patients (52) during the study period to make this study more powerful.

4.7. Study Variables

4.7.1. Dependent variables

- Functional outcome of the elbow, MEP Score (excellent, good, fair and poor)

4.7.2 Independent variables

- Socio-demographic profile (Age, Gender)
- Mechanism of injury
- Limb side preference
- Any associated injury
- Post-operative complications
- Pre-operative stay
- Implant used for fixation
- Post-operative rehabilitation

4.8. Operational Definition

- Bi-Columnar fixation; fixation of both medial and lateral columns of distal humerus with either orthogonal (one medial and another posterolateral) or parallel plating (one medial and the other lateral).
- Post-operative rehabilitation; Post-operative rehabilitation: A series of exercises and therapies done by a patient under the supervision of a medical professional following a surgical procedure. Home based range of motion in that the participant performs a range of motion (ROM) exercise for the elbow joint independently at home, without any

guidance or supervision from a physiotherapist. The exercise involves moving the elbow joint in various directions. this study used home based range of motion as Post-operative rehabilitation.

- Locking plate; specialized type of surgical plate used to provide strong and stable fixation for bone fractures. Conventional plates like Dynamic compression plates rely on friction between the plate and bone to provide a stable repair construct that counteracts the forces to which the healing fracture are subjected.
- Y-plate -Y-shaped plate placed on dorsal surface of distal humerus in inverted fashion.
- MEPS; Mayo Elbow Performance Score; is the most commonly applied elbow-specific outcome measure.¹⁸It is a physician -based score that assesses pain, motion, stability and function with weightings of 45%, 20%, 10% and 25%, respectively.
 - ✓ Excellent >90
 - ✓ Good 75-89
 - ✓ Fair 60-74
 - ✓ Poor <60

4.9. Data collection tool and procedure

A well-structured, self-filled, predesigned and pretested Proforma checklist was developed in English from reviewed literatures and standard books by the principal investigator. Data was collected by two questionnaires; study-specific questionnaire and functional outcomes questionnaires using MEPS. Study-specific questionnaire was used to collect data from patients' chart manually, Remote eye (local net-work for x-ray review) and Standardized MEP score questionnaires was filled mainly by the principal investigator and orthopedic residents from patients coming for regular OPD follow up. Patients who could not return to the clinic were interviewed by phone and reviewed by a local physician. MEPS is the most commonly applied elbow-specific outcome measure (18). It is a clinician-based score that assesses pain, motion, stability and function with weightings of 45%, 20%, 10% and 25%, respectively. This score is widely applied to all elbow pathology including trauma (26) and it is a 4-part test where clinical information is rated based on a 100 points scale (<60 – poor, 60-74 – fair, 75-89 – good, 90-100 excellent). The validity and reliability of MEP scores has been shown to be good.

Table 1; Mayo Elbow Performance score (MEPS

Activities	Definition	Points	Score classification
Pain	No (45)	45	Excellent >90
	Mild (30)	30	
	Moderate (15)	15	
	Severe (0)	0	
Range of motion (degree of flexion)	>100(20)	20	Good 75-89
	50-100(15)	15	
	<50(5)	5	
Stability	Stable (10)	10	Fair 60-74
	Mildly unstable (5)	5	
	Unstable (0)	0	
Activities of daily living	Combing your hair (5)	5	Poor <60
	Performing personal hygiene (5)	5	
	Eating (5)	5	
	Putting on shirt and shoes (5)	5	
Total score =-----100%			

4.10. Data Quality Assurance

- Data entry and coding was done by using Statistical Package for Social Sciences (SPSS) version 26. and Data was cleaned with consistency checks and any errors identified at that time were corrected after revision of the original data using the code numbers. To keep the quality of data the predesigned semi structured proforma was pretested and anything which is unclear and ambiguous, were leveled after discussing with the respective personnel. About 10% of the data were double entered by the principal investigator to check consistency in putting data to SPSS.

4.11. Data processing and Analysis

The data was analyzed by the same SPSS package software, after appropriate data rechecking, Descriptive statistical analysis conducted, for categorical variables, frequency distribution and percentages were used for summarization and for continuous variables, appropriate measures of central tendency and measures of dispersion was applied. The degree of association between dependent and independent variables was determined by Multivariable ordinal logistic regression, One Way ANOVA with CI of 95% and p-value of <0.05. Clinical outcome was measured by MEP score. Finally, the findings were presented by using text, tables and graphs as appropriate.

4.12. Ethical Clearance

Ethical clearance was obtained from the Institutional Review board (IRB) of Saint Paul's Hospital and Millennium Medical College. Information used in this study was anonymized. Study numbers were assigned to individual cases, and the information was stored on a password-protected computer. Waiver of informed consent was granted by the IRB, because of the anonymization of the data, the difficulty of reaching the patients and anything that disclosed the identification of the patient was not used in the research.

5. Result

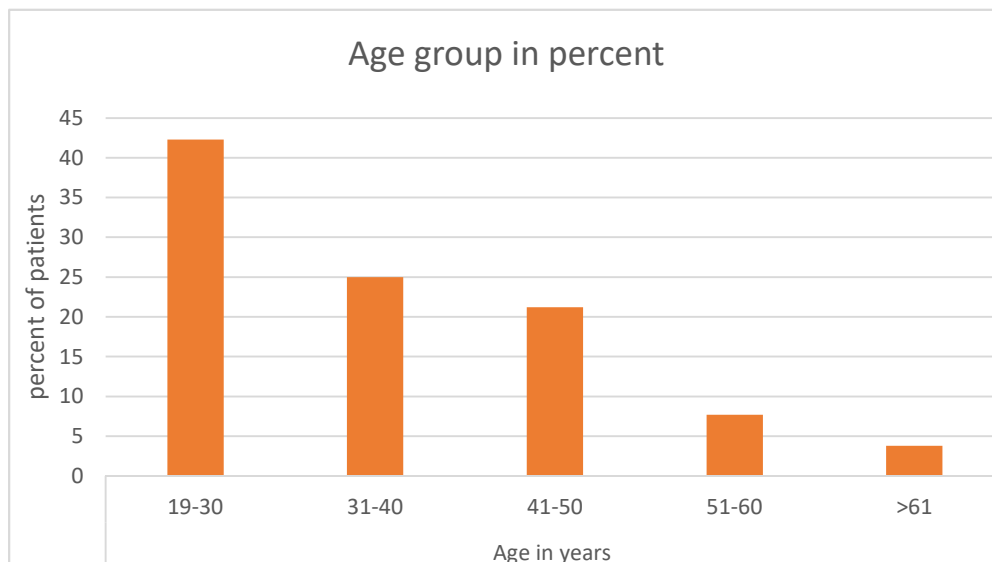
5.1. Socio Demographic characteristics of the study population

This study consists of 52 cases of distal humerus fracture treated by open reduction and internal fixation of both medial and lateral column. The participants were composed of 39(75%) males and 13(25%) females.

Table 2; Socio Demographic characteristics of the study participants, AABET hospital, 2023

Gender	Frequency	Percent	Mean	Std. Deviation
Male	39	75	31.74	9.176
Female	13	25	47.46	13.974

A significant proportion (42.3%) of individuals were within the age group of 19 - 30 years. The range of age was between 19-65 years and the mean age was 35.67($\pm$ 12.49).



Bar chart 1: Percent Distribution of participants according to age group

5.2. Variables related to fracture character

Majority of the patients sustained injury to their left upper extremity. In the mechanism of injury, 21(40.4%) patients sustained fractures following road traffic accidents and 18 (34.6%) sustained fracture due to falling down accident. Open fractures accounted for 13 (25%) and all of them are Gustillo Anderson grade one. 21% patients had other associated injuries at the time of presentation, of these 6 patients had associated ipsilateral forearm injury, two patients had nerve

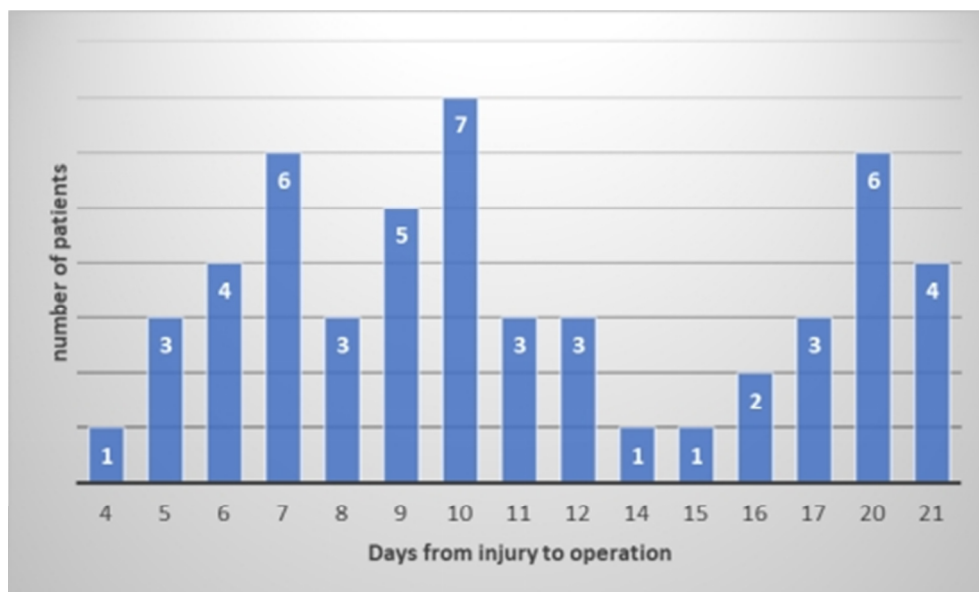
injury, two had associated long bone fracture (Tibial or Femur). According to the AO classification 9 patients had 13A, 14 patients had 13B and 29 patients had 13C fractures.

Table 3: Variables associated with fracture character, AABET hospital, 2023

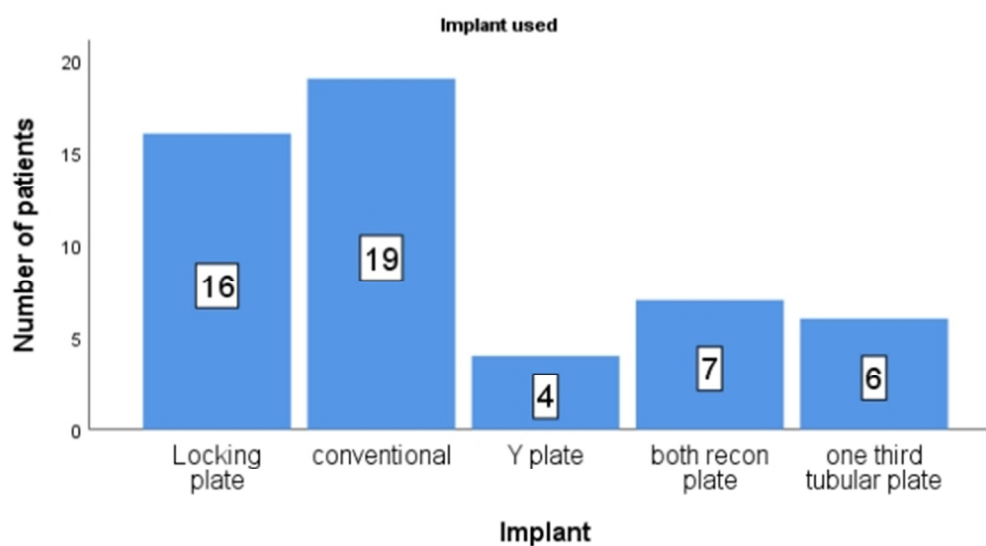
Variable		Frequency	Percentage
Mechanism of injury	Road traffic accident	21	40.4
	Stick injury	8	15.4
	Fall down accident	18	34.6
	Bullet injury	3	5.8
	Machine injury	2	3.8
Side of the injured limb	Right	20	38.5
	Left	32	61.5
Distal humerus fracture AO classification	13A	9	17.3
	13B	14	26.9
	13C	29	55.8
Type of fracture	Open	13	25.0
	Closed	39	75.0
Associated injury	Ipsilateral forearm fracture	6	11.5
	Thoraco- abdominal injury	1	1.9
	long bone #	2	3.8
	Nerve injury	2	3.8
	No associated injury	41	78.8

5.3 Frequency distribution of pre-op stay and Implant choice

There was an average delay of 12($\pm$ 5.3) days (distribution 4- 21 days) between date of injury and date of surgery. Majority of the fixations were with conventional plate (19) and Locking plate (16).



Bar chart 2: Frequency Distribution of patients according to time between injury and surgery



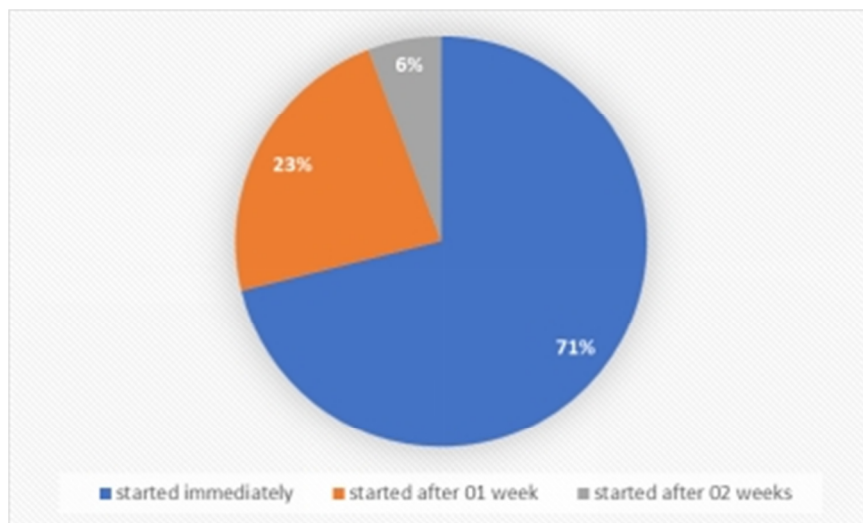
Bar chart 3: Frequency Distribution of patients according to implant types

Table 4; Comparing Variables with their Respective mean mep score

Variables	Frequency	Mean MEPS	Std. Deviation
Implant used			
Locking plate	16	79.38	9.811
Conventional	19	78.42	8.983
Y plate	4	67.50	8.660
Both recon plate	7	75.71	7.868
One third tubular plate	6	64.17	3.764
Post-op rehabilitation			
started immediately	37	79.32	8.673
started after 01 week	12	69.17	5.967
started after 02 weeks	3	60.00	8.660

5.4 Variables related to complications and rehabilitation

Complications encountered in this study were, stiffness, nerve injury and infection. Stiffness was the commonest Complication.



Pie chart 2: Distribution of patients according to time of start of physiotherapy

Table 5; post-op Complications

Complications	Frequency	Percent
No complication	19	36.5
Infection	4	7.7
Stiffness	24	46.2
Nerve injury	5	9.6

The Mayo Elbow Performance Score (MEPS) was used to conduct a functional assessment of the patient. Based on the MEP score, the clinical outcome was as follows: excellent in 10 patients (19%), good in 22 patients (42.3%), fair in 18 patients (34.6%), and poor in 2 patients (3.8%). The mean MEP score was 75.87($\pm$ 9.88), with a maximum score of 95 and a minimum score of 55. As a result, 61% of the patients had good to excellent outcomes.

Table 6; Functional Outcomes according to MEPS

MEPS Group	Frequency	Percent
Excellent	10	19.2
Good	22	42.3
Fair	18	34.6
Poor	2	3.8

5.5 Univariate ordinal logistic regression analysis

Univariate ordinal logistic regression analysis was carried out to assess if there was an association between functional outcome of bicolunar fixation of distal humerus fractures and the independent variables. When comparing sociodemographic characteristics with functional outcome, no statistically significant association was found. Delayed pre-operative stay had 1.535 times likely to have worse functional outcome.

Table 7; Univariate ordinal logistic regression for factor that have significant effect on clinical outcome.

Variable	Functional Outcome AOR (95% CI)	P- value
Pre-operative stay	1.535(1.273,1.851)	.000

5.6. Multivariable ordinal logistic regression for factor that have significant effect on clinical outcome.

Using the independent variable which was significant (pre-operative stay) on univariate ordinal logistic regression analysis; multivariable ordinal logistic regression was carried out by including all variables to adjust for cofounders. it was found that as length of preoperative stay increases the odds of having worse (fair or poor) functional outcome increases by 1.74 times as compared to the odds of having good or excellent functional outcome [AOR 95% CI: 1.74 (1.31,2.313)]. Prolonged pre-op stays (delayed surgery) has significant effect on clinical outcome.

Table 8; Multivariable ordinal logistic regression for factor that have significant effect on clinical outcome.

Variable	Functional Outcome AOR (95% CI)	P- value
Pre-operative stay	1.74(1.31,2.313)	.000

5.7 One-way ANOVA analysis was done to compare mean MEP scores of three or more independent groups (post-op physiotherapy and implant used)

After assumption are checked, fishers Least Significance Difference (LCD) as the post hoc test and Bonferroni correction were done (p=0.007) for categorical variables with greater than three groups, One- way ANOVA analysis was undertaken.

Table 10; One-way ANOVA analysis of factors that have significant association with the clinical outcome.

(I) Post-op rehabilitation	(J) Post-op rehabilitation	Mean Difference (I-J)	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
started immediately	started after 01 week	10.158 [*]	.000	4.72	15.59
	started after 02 weeks	19.324 [*]	.000	9.50	29.15
started after 01 week	started immediately	-10.158 [*]	.000	-15.59	-4.72
	started after 02 weeks	9.167	.087	-1.40	19.73
(I) implant used	(J) implant used				
Locking plate	one third tubular plate	15.208 [*]	.001	6.82	23.59
Conventional plate	one third tubular plate	14.254 [*]	.001	6.05	22.46

There was statistically significant difference in the mean mep score between groups of post-op rehabilitations determined by one-way ANOVA ($F(2,49)=13.090$, $P<0.001$).LCD post hoc test revealed that the mean mep score was statistically significantly lower when post-operative rehabilitation begun after two weeks (60 ± 8.66) and when started after one week(69.17 ± 5.9) compared to post-operative rehabilitation that begun immediately(79.3 ± 8.6).there was no statistically significant difference in the mean mep score between groups of post-op rehabilitations more than one and two weeks starters ($p=0.87$).

The mean outcome score of both locking anatomic plates (78.67 ± 9.72) and conventional plates (77.81 ± 9.304) were higher as compared to outcome score of one-third tubular plates (64.17 ± 3.764). ($F(4,47) = 4.424$, $P = 0.004$ Bonferroni correction for $p = 0.007$). There were no significant association between mechanism of injury, associated injury, side of injury with clinical outcome.

6. Discussion

This study investigated the prevalence of clinical outcome and assess effects of delayed surgery, delayed physiotherapy and implant choice on functional outcome in patients with distal humerus fractures treated with bi-columnar fixation. Males made up 75 percent of the subjects in this study and female made up of 25%. This is comparable to study by Shaik RB et al. (10), in which the male to female ratio was 3:1. Male predominates probably due to their increased involvement in outdoor physical activities.

Among this road traffic and falling down accidents occupies majority of cases of this study and an average age at fracture was 35 years, and from mechanism of injury road traffic accidents accounted for 40 % of the cases.

These findings are in line with those of a research conducted by Vasishta D et al (5), found age range of 19-65, average age of 38 years, road traffic and falling down accidents occupies majority of cases. Study by Thapa, Jha and Rajthala, had similar age range of 19 – 68 years old comparable to this study which had an age group of 19-65. (19). The average age of patients in study by Sunil et al. was 37.5(17). This indicates that distal humerus fractures are more common in men of working age who are involved in high-energy trauma.

This study found that the left side was more frequently involved (61.5%) than the right side, which is similar to the findings of TH et al. (63.3%) (12) and Sreedhar Reddy et al. (62.86%). We also observed that closed fractures accounted for 75% of the cases, which is a figure comparable to the study by Sreedhar Reddy et al., where 74% of distal humerus fractures were closed (4) .

In our study, elbow stiffness was the most common complication encountered, with a frequency of 46%, a figure that is comparable to the 46.5% reported by Han et al (21). Dinesh et al. also reported similar findings, with elbow stiffness being the most common complication encountered (27). Additionally, our study found infection rates of 7.7%, and nerve-related complications were encountered in 9.6% of cases, a figure comparable to the 7.7% wound site infection and 7.7% nerve-related complications reported by Asfuroğlu et al.

The Mayo elbow performance score was used to perform an objective functional assessment, with results indicating 19.2% excellent, 42% good, 34.6% fair, and 3.8% poor clinical outcomes. The mean MEP score of this study was 75.87 ± 9.88 . These results were found to be comparable with a study by Theivendran et al., wherein the mean MEP score was 72.3 ± 16.4 (18).

The findings of this study reported that 47% (14% excellent and 33% good) of the patients had excellent and good outcomes, while 33% had fair outcomes, and 20% had poor outcomes. Asfuroğlu et al. conducted a similar study and reported comparable results, wherein 48.7% of patients had excellent and good outcomes. (21).

Senthilnathan et al. reported good to excellent outcomes (85%) after using an anatomic locking plate to fix all type C distal humerus fractures (20). In studies by Atalar et al., Shaik, P. and K., Rosenlund, Søreide, and Madsen, the mean Mayo elbow performance score was 86, 84, and 85, respectively. The use of a pre-contoured anatomic plate may explain these results as it enables stable fixation and early physiotherapy for patients compared to our study.

Chigblo et al. conducted a study in Benin and found that the mean MEPS score was 66.3 points after using surgical fixation with Lecestre plate + 1/3 tubular plate in the majority of cases (55%). The average time to surgery was 21 days, and patients began physiotherapy within an average of 13 days (range: 5-49 days). In contrast, Kural et al. reported a mean time of 5 days (range: 1-15 days) before surgery, while Rosenlund et al. and Asfuroğlu et al. reported mean

time before surgery of 3 days (range: 0-28 days) and 3.8 days (range: 1-16 days), respectively in which all showed better outcomes. Our study had a mean time of 12 days before surgery (range: 4-21 days) comparable to Chigblo et al. The delay in surgery in this study was due to patient overload, a stay in a peripheral center, being on an external fixator, and a lack of financial means. These findings suggest that delays in surgery and physiotherapy may result in worse outcomes.

This study observed that 6% of the patients began regular home-based physiotherapy after 2 weeks, while 23% started after 1 week. Among the 3 patients who started physiotherapy after 2 weeks, two had poor outcomes, and one had a fair result. The average MEP score of patients who started physiotherapy late was 63. The study by Korner et al. supported these ideas, as they reported that 63% of patients with poor or fair results had been immobilized for 14 days or longer without physiotherapy (21). Stability of fixation is very important, to start early rehabilitation and get better result. This is supported by Senthilnathan et al., fixed all AO type 13C with pre-contoured Anatomical Locking Compression plates, found 85% fracture union by 4 months, no implant failure except k-wire protrusion in one patient and excellent (70%) and good (15%) result in 85% of the patients (20).

There is significant association between delay of surgery and clinical outcome ($p < 0.05$). There was statistically significant difference in functional outcome when physiotherapy is delayed compared with early physiotherapy ($p < 0.05$). There was also statistically significant difference in functional outcome when one third tubular plates are used compared to locking or conventional plates ($p < 0.05$).

The use of one third tubular plates, delay of surgery, delayed start and home physiotherapy were resulted in worse functional outcome. As most of the results were from western countries, being in low income country could be another reason for worse outcome.

7. Limitations of the study

- The study cannot be generalized as the study population was drawn from one institution
- The study is a cross sectional study and hence cannot establish a cause and effect relationships

- The sample size was small

8. Conclusion

According to the findings of this study, the clinical outcome of distal humerus fractures fixed with bi-columnar fixation is worse than in other studies, as indicated by a mean MEP score of 76.

Based on the findings of this study, it can be concluded that, delay in surgery, use of non-locking plates, delayed initiation of post-operative rehabilitation and home-based physiotherapy, and being from a low-income country were all associated with worse clinical outcomes. Stiffness is the most common complication of these fractures' fixation. This research highlights the importance of early surgical intervention, the use of locking plates instead of non-locking plates, and prompt initiation of physiotherapy to achieve better clinical outcomes.

9. Recommendation

To decrease the incidence of distal humerus fractures associated with road traffic accidents, measures to reduce the frequency of such accidents should be implemented on a wide scale. In cases where surgery is required, facilitating early intervention and using locking anatomic plates can help improve clinical outcomes. Involving the department of physiotherapy in the early stages of post-operative rehabilitation is also important.

Before undergoing surgery, patients should receive detailed instructions explaining how the outcome of the procedure largely depends on their motivation to regain function. To gain a better understanding of the factors associated with poor clinical outcomes in distal humerus fractures, it is recommended that similar studies be conducted on a nationwide scale. Furthermore, to validate these findings and identify other factors that may contribute to better clinical outcomes following bi-columnar fixation for distal humerus fractures, more extensive research with larger sample sizes and diverse populations is needed.

References

1. Rockwood and Green 9th edition.
2. Singh D, Singh A, Sareen S, Sandhu A. Comparative study of functional outcome of distal humerus intra-articular fracture treated with parallel plates and with orthogonal plates (a study of 30 cases). *Eur J Mol Clin Med* [Internet]. 2021;8(4):39-52. Available from: <https://www.cochranelibrary.com/central/doi/10.1002/central/CN-02303577/full>
3. Kural C, Ercin E, Erkilinc M, Karaali E, Bilgili MG, Altun S. Bicolumnar 90-90 plating of AO 13C type fractures. *Acta Orthop Traumatol Turc* [Internet]. 2017;51(2):128–32. Available from: <http://dx.doi.org/10.1016/j.aott.2016.09.003>
4. Sreedhar Reddy U, Samorekar B, Mathew VJ, Mettu AK. Functional outcome of elbow joint in AO type 13C fractures treated with open reduction and internal fixation using dual plates. *Int J Res Orthop*. 2019;5(3):509.
5. Vashistha D, Naik S, Nandi S, Kulkarni S. Clinical outcome of treatment of intra-articular distal humerus fracture with open reduction and internal fixation by orthogonal locking plate: a prospective study. *Int J Res Orthop*. 2020;6(3):471.
6. Profmrrajasekar Msortho K, Dean Director Do, Mrrajasekar Msortho P. CERTIFICATE

- under guidance and supervision in the Institute of Signature of the Guide. 2010;(April).
7. Sahu RL. Functional outcome following internal fixation of intraarticular fractures of the distal femur. *Acta Orthop Belg.* 2017;83(2):215–22.
 8. Resident S, Resident J, Resident S. Functional outcomes of dual plating of distal humerus fractures with triceps tongue method. 2022;09(03):1567–73.
 9. Ek ETH, Goldwasser M, Bonomo AL. Functional outcome of complex intercondylar fractures of the distal humerus treated through a triceps-sparing approach. *J Shoulder Elb Surg.* 2008;17(3):441–6.
 10. Shaik RB, P. VR, K. AN. Study of clinical outcome in intra articular distal humerus fractures treated with dual plating. *Int J Res Med Sci.* 2017;5(6):2438.
 11. Atalar AC, Demirhan M, Salduz A, Kilicoglu O, Seyahi A. Functional results of the parallel-plate technique for complex distal humerus fractures. *Acta Orthop Traumatol Turc.* 2009;43(1):21–7.
 12. TH DP, P DA, M DBP. Functional outcome of distal humerus fracture in adults treated with Bicolumnar plating: A prospective study. *Int J Orthop Sci.* 2020;6(2):155–60.
 13. Gofton WT, MacDermid JC, Patterson SD, Faber KJ, King GJW. Functional outcome of AO type C distal humeral fractures. *J Hand Surg Am.* 2003;28(2):294–308.
 14. Rosenlund AN, Søreide E, Madsen JE. Outcomes and complications after open reduction and internal fixation of distal humeral fractures with precontoured locking plates. :7–11.
 15. Virani SR, Sonone S, Dahapute AA, Panda I, Roy KD. Functional results of comminuted intra-articular distal humerus fractures treated with bicolumnar plating. *J Clin Diagnostic Res.* 2017;11(4):RC01–3.
 16. Sata VR, Agarwal A. A Comprehensive Study of Functional Outcome in Supracondylar Intercondylar Fracture of Humerus in Adults. 2020;9(2):2018–21.
 17. Sunil B, Avulapati SK, Choudhary SK, Koneru S. Functional outcome evaluation of distal humerus fracture fixation. *Int J Res Orthop.* 2020;6(3):467.
 18. Theivendran, K., Duggan, P. J., & Deshmukh, S. C. (2010). Surgical treatment of complex distal humeral fractures: Functional outcome after internal fixation using precontoured

- anatomic plates. *Journal of Shoulder and Elbow Surgery*, 19(4), 524–532.
<https://doi.org/10.1016/j.jse.2009.09.011>
19. Thapa S, Jha RK, Rajthala A. FUNCTIONAL OUTCOME OF INTERCONDYLAR DISTAL HUMERUS FRACTURES SURGICALLY TREATED WITH OPEN REDUCTION AND INTERNAL FIXATION WITH A PRINCIPLE BASED ON. 2021;6(1):1336–40.
 20. Senthilnathan DA, Prabhakar DR, Parasuraman DK, Shankar DKV, Chander DSN. Functional outcome of distal humerus fracture in adults followed with bicolumnar fixation: A prospective study. *Int J Orthop Sci*. 2022;8(1):173–9.
 21. Asfuroğlu ZM, İnan U, Ömeroğlu H. Open reduction and internal fixation in AO type C distal humeral fractures using olecranon osteotomy: Functional and clinical results. 2018;24(2):162–7.
 22. Huang JI, Paczas M, Hoyer HA, Vallier HA. Functional Outcome After Open Reduction Internal Fixation of Intra-articular Fractures of the Distal Humerus in the Elderly. 2011;25(5):259–65.
 23. Moursy M, Wegmann K, Wichlas F, Tauber M. Distal humerus fracture in patients over 70 years of age: results of open reduction and internal fixation. *Arch Orthop Trauma Surg* [Internet]. 2022;142(1):157–64. Available from: <https://doi.org/10.1007/s00402-020-03664-4>
 24. Chigblo SP, Gbessi GD, Amoussou F, Padonou A, Tidjani IF, Lawson E, et al. Results of surgical treatment of distal humerus fractures in adults in Cotonou. 2022;9(2):298–303.
 25. Savvidou OD, Zampeli F, Koutsouradis P, Chloros GD, Kaspiris A, Sourmelis S, et al. Complications of open reduction and internal fixation of distal humerus fractures. *EFORT Open Rev*. 2018;3(10):558–67.
 26. Little C, Harvie P, Carr A. Outcome Measures in Surgery of the Elbow. *Oper Elb Surg Expert Consult Online Print*. 2011;705–16.
 27. Dinesh, S. et al. (2016) 'Functional Outcome of Patients Treated with Bicolumn Fixation in Distal Humerus Fractures: A Prospective Study', *International Journal of Scientific Study*, 4(8), pp. 192–195. Available at: <https://doi.org/10.17354/ijss/2016/597>.
 28. Korner, J., Lill, H., Müller, L. P., Hessmann, M., Kopf, K., Goldhahn, J., Gonschorek, O.,

Josten, C., & Rommens, P. M. (2005). Distal humerus fractures in elderly patients: Results after open reduction and internal fixation. *Osteoporosis International*, 16(SUPPL. 2), 73–79. <https://doi.org/10.1007/s00198-004-1764->

29. Mao, J. T., Chang, H. W., Lin, T. L., Lin, I. H., Lin, C. Y., & Hsu, C. J. (2022). Clinical Outcomes of Single Versus Double Plating in Distal-Third Humeral Fractures Caused by Arm Wrestling: A Retrospective Analysis. *Medicina (Kaunas, Lithuania)*, 58(11).

ANNEXES

Data Collection Checklist/proforma

Checklist to collect data on retrospective cross-sectional study of functional outcome of distal humerus fracture patient treated with bi-columnar fixation at AaBET hospital from 2016 to 2021, Addis Ababa, Ethiopia

Table 10 a: Study specific questionnaires'

Data Collector name: -----, **Signature:** -----, **Date:** -----,

S. No.	The study variables	Response	Remark
1	MRN	_____	
2	Phone number	_____	
3. Socio-demographic profile of the participants			
	Sex	1. Male	

		2. Female	
	Age	_____	
	Area of residency (region)	_____	
4. History of the trauma of patient who presented to AaBET hospital			
	Mechanism of injury	1. Road traffic accident 2. Motor vehicle accident 3. Sport injury 4. Stick injury 5. Fall down 6. Bullet injury 7. Other(specify)_____	
	Limb side	1. Right 2. left	
	Type of fracture (AO classification)	1. 13A_____ 2. 13B_____ 3. 13C_____	
	Type of distal humerus fracture based on soft tissue involvement	1. Closed_____ 2. Open (Specify)_____	
5. Treatment given			
	After how many days of the	Specify in days _____	

	injury was the operation?		
	What implant is used?	1. Locking plate 2. Conventional plate (DCP or LCDCP) 3. Both sides Recon plate 4. Y plate 5. One third tubular plate	
6. Postoperative rehabilitation		Time at which Home and physiotherapist guided Rom started	
7. post-operative complications			
	Infections		
	Joint stiffness		
	Nerve injury		
	Implant failure		
9. post-operative MEPS=			

Table 10 b. Mayo Elbow Performance score (MEPS) questionnaires

Activities	Scale of difficulties (Point)	
Pain	No (45)	
	Mild (30)	
	Moderate (15)	
	Severe (0)	
Range of motion (degree of flexion)	>100(20)	
	50-100(15)	
	<50(5)	
Stability	Stable (10)	
	Mildly unstable (5)	
	Unstable (0)	

Activities of daily living	Combing your hair (5)	
	Performing personal hygiene (5)	
	Eating (5)	
	Putting on shirt and shoes (5)	
Total score =-----100%		

Comments / Interpretation:

Name of data collector _____ signature _____ date_____

Name of Investigator _____ signature _____ date_____