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Clinical Effectiveness And Efficiency Of The Anatomical Distal Fibular Plate In Lateral Malleolus Fracture Fixation

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ORIGINAL ARTICLE

Clinical Effectiveness and Efficiency of the Anatomical Distal Fibular Plate in Lateral Malleolus Fracture Fixation

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Abstract

Background: Ankle fractures are among the most frequent injuries, and distal fibular fractures are the form of ankle fracture that is most often sustained by young, active people. In order to get the greatest results, the lateral malleolar fracture should be treated in a way that restores length, maintains fibula alignment, and keeps the lateral malleolus stable.

Aim and objectives: To evaluate Clinical effectiveness and efficiency of the anatomical distal fibular plate in lateral malleolus fracture fixation.

Patients and methods: This prospective study includes twenty cases (8 males and 12 females) of lateral malleolus fractures. Treated by anatomical plates at Al-Azhar University Hospitals (Al-Hussien and Sayed Galal hospital). All Patients were followed between January 2022 and April 2023.

Results: This investigation included 20 patients who attended the emergency of Al-Azhar hospitals with lateral malleolus fracture and did fixation by anatomical plate. They are routinely followed for functional assessment according to American orthopedic foot and ankle society showed 16 patients with excellent results of about 80 %, three patients showed good results about 15 % and one patient showed fair final outcome. Patients achieved initial pain relief in 90 % of our patients. Fortunately, it is well tolerated in the large majority of patients. In our series, no clinical symptoms were connected to the plate. In addition, we used conventional radiography for follow-up in our study.

Conclusion: The use of an anatomical distal fibular plate in lateral malleolar fracture gives stability, this will be achieved by the contour of the plate, its thickness, and the distribution of the holes. Also provides good functional outcomes as regards to medical outcomes study (MOS) and the American orthopedic foot and ankle society.

Keywords: Anatomical distal fibular plate, Lateral malleolus fracture, Outcomes assessments

1. Introduction

Ankle fractures are frequent, occurring up to 174 cases/100 000 adult adults/year. For clinical results, their proper categorization and management are crucial. The crucial information concerning malleolar fractures is that they cause intra-articular injuries and that soft tissue damage is frequent since the bones are located under the skin.

The most frequent kind of fracture is an unimalleolar fracture (68 %) followed by bimalleolar fractures (25 %) and tri-malleolar fractures.¹

The ankle joint is a complex joint in which bones, ligaments, and muscles play an important role in stability and function. Being a weight-bearing joint the ankle is subjected to forces that are roughly 1.25 times the body weight during normal gait and as high as 5.5 times the body weight during vigorous

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activity.² Fractures of the lateral malleolus have been classified by Denis Weber classification into: Type A: fractures are infra-syndesmotic and usually caused by avulsion fracture, Type B: fractures are *trans*-syndesmotic occurring after torsional injuries (this is the most common type), and Type C: fractures are supra-syndesmotic (less common type).³

With the greatest results, the lateral malleolar fracture is treated to restore length, straighten the fibula, and preserve the stability of the lateral malleolus. Standard treatment for displaced and unstable lateral malleolar fractures involves surgery with open reduction and internal fixation.⁴

For lateral malleolar fractures, there are numerous fixation options, including locking anatomical plates with or without an independent lag screw, dynamic compression plates, and one-third tubular plate fixation. The locking plates provide protected blood flow and accelerate bone healing in ankle fractures by reducing periosteal compression.⁵

Although the use of locking anatomical plates is regarded as a conventional surgical strategy for osteoporotic or short-end-segment fractures, there is conflicting evidence about the kind of locking plates that should be used for the distal fibular fracture, either a locking tubular or a locking pre-shaped anatomic plate. The synthetic locking compression plate system, which combines locking screw technology with traditional plating processes, includes the anatomical distal fibular plate. The plates come in titanium and stainless steel. The plates have an anatomical form and contour throughout the fibular shaft as well as distally. The dynamic compression unit hole and the locking screw hole are combined in the combi-holes on the locking compression plate shaft.⁵

The purpose of the study was to assess the clinical efficacy and efficiency of the anatomical distal fibular plate in the treatment of lateral malleolus fractures.

2. Patients and methods

This prospective study involves 20 cases of lateral malleolar and ankle fractures. Treated by anatomical distal fibular plates at Al-Azhar university hospitals (Al-Hussein and Sayed Galal hospital). Patients were followed between January 2022 and April 2023. In our study, we evaluated 20 patients the youngest patient was 20 years old, and the oldest was 68 years old. The median age was (42.94) years with an interquartile range (of 42.94), with 40 % male, and 60 % female.

In our patients, lateral malleolus fractures were treated with open reduction and anatomical plate fixation.

The group was found to have 12 cases of lateral malleolus fracture only, seven patients of pott's fracture, and one patient with ankle dislocation.

After open reduction and fixation by anatomical plate, all patients had to put in below knee slab for 4–6 weeks. This assessment related to the pain and delay weight bearing till union start.

Follow-up visits at 2, 4, and 6 weeks and on 3, 6 months postoperatively.

At the first visit patients were assessed regarding pain, wound and neurovascular. Then on fourth week they were assessed regarding wound and callus by radiography. On the 6th week they start partial weight bearing and remove the slab. Then they routinely followed and assessed functionally regarding Olerud-Molander Score and American orthopedic foot and ankle society (AOFAS).

Our patients are described in the following tables to show the distribution of sex [Table 1](#), distribution of age [Table 2](#), grouping of the mode of trauma [Table 3](#).

2.1. Clinical evaluation

Preoperative evaluation: the patients were managed according to age and comorbidities. The patient should be assessed clinically, laboratory, and radiologic.

Patients were initially treated with leg elevation and medical treatment to control edema. Patients with moderate to severe edema of the foot and ankle were not operated upon until having a positive wrinkle test.

Clinically: general examination (Systemic examination searching for associated injury, deformity), Local examination (Scar for previous surgeries,

Table 1. Distribution of patient sex.

Sex	Number (Percentages)
Males	8 (40 %)
Females	12 (60 %)
Total	20 (100)

Table 2. Distribution of patient age.

	Mean \pm SD	Min	Max
Age range (years)	42.94 \pm 12.08	20	68

Table 3. Grouping of the fracture.

Lateral malleolus only	12	60 %
Potts fracture	7	35 %
Ankle dislocation	1	5 %

deformity, and site of pain), Neurovascular examination: peripheral pulsation, sensation and capillary refill test (CRT) and Laboratory: complete blood count, prothrombin time (Pt), partial thromboplastin time (Ptt), international normalised ratio (INR), liver function test, kidney function test.

Radiological: Standard antero-posterior, lateral and mortise of ankle joint and antero-posterior, lateral of ipsilateral knee radiographs were obtained in all patients before operation computed tomography scan for planning and to assess the articular surface specially with pott's fractures and ankle dislocation.

Computed tomography scan for planning and to assess the articular surface specially with pott's fractures and ankle dislocation.

Magnetic resonance imaging (MRI): may needed for soft tissue assessment specially with ankle dislocation.

This preparation was done to plan for management.

Inclusion criteria: Osteoporotic fractures and adult patients with lateral malleolus and ankle fractures of bi-malleolar, pilon, and tri-malleolar fractures.

Exclusion criteria: Patients less than 15 years old, patients with peripheral vascular disease, presence of severe comorbidities, patients with active infection and open fractures.

Timing of surgery: Surgery time is mostly determined by the health of the soft tissue around the ankle.

Surgical technique: three out of the 20 patients were given epidural anesthesia. The rest of the patients were all given spinal anesthesia. The surgical technique was adopted from the AO Trauma surgery reference approach to lateral malleolus fractures (28). All patients were operated upon in the supine position. a thigh tourniquet was used in all patients.

A direct lateral skin incision is utilized extending distal to the tip of the lateral malleolus. The incision is placed either slightly anterior or posterior so that the plate does not lie directly below the incision. Superficial dissection is through an intermuscular plane between the peroneus Tertius anteriorly and both peroneal brevis and longus posteriorly.

Care must be taken not to injure the superficial peroneal nerve (anterior) or the sural nerve (posterior), if discovered must be protected, and retracted downward by a langenbeck tissue retractor. (Fig. 1).

Closed reduction and reversal of the mechanism of injury was the main method used for fracture reduction. After the fracture is cleaned, the lateral malleolus is reduced anatomically utilizing a bone holder and then held with a bone holder and Kirschner wire. The whole Procedure is done under fluoroscopic imaging guidance. (Fig. 2).



Fig. 1. Incision line.

The locked plate is inserted then the power drill is used to drill a hole for the most proximal screw first to achieve compression of the fracture, then the one after till the most distal screw. (Fig. 3a and b).

The reduction, screw length, and position are all checked in anteroposterior, lateral, and mortise views intraoperatively by fluoroscopy. Wounds were irrigated after fixation and sutured by 3/0 pro-line sutures. A below knee splint is applied. (Fig. 4).

2.2. Postoperative care

Immediate postoperative care: Immediately postoperative deep-vein thrombosis (DVT) prophylaxis was prescribed. Postoperative anteroposterior, lateral, and mortise views are obtained immediately after surgery. Third-generation cephalosporin was administered intravenously to all patients for three days after surgery. On the fourth day, oral administration of the drug was introduced. Following the surgery, the dressing was changed the next day and then every 3 days following that. After 2 weeks stitches are removed and the below knee Splint is changed if necessary. Patients are scheduled every 2-week follow-up visit. At 6 weeks postoperative the patient is advised to encourage ankle range of motion (ROM) while weight bearing is still Prohibited. At 8 weeks postoperative partial weight bearing in



Fig. 2. Reduction and plate holding.

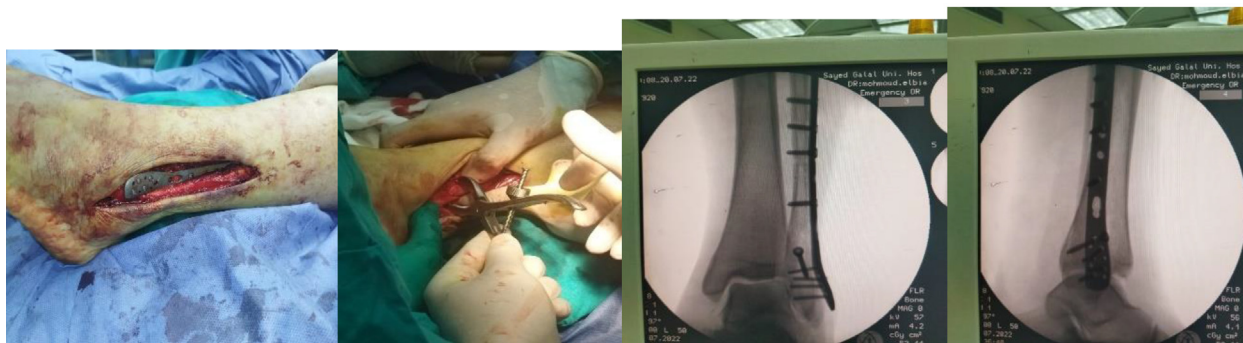


Fig. 3. (a) C-arm drilling for locked plate medial malleolus. (b) insertion of locked plate (c) C-arm fixation by locked plate.

the form of tip-toeing is encouraged as tolerated, which gradually progresses to full weight bearing over the following monthly visits. Assessment for the need for hardware removal is done at 9 months and according to the patient's preference.

2.3. Outcome measures

Clinical evaluation: One of the most widely used tools for assessing the effectiveness of therapy for individuals with complicated ankle or hindfoot injuries is the AOFAS Ankle-Hindfoot Score. It combines a patient-reported portion with a clinician-reported part.⁶ Developed by Kitaoka et al.,⁷ this clinical rating system combines the patient's subjective pain and function scores with objective scores based on the surgeon's physical assessment of the patient (to evaluate sagittal motion, hindfoot motion, ankle-hindfoot stability, and ankle-hindfoot alignment). Nine components make up the scale, which has three subscales (pain, function, and alignment). The only item in the pain category has a maximum score of 40, which denotes the absence of pain. Seven things make up the function, and a score of 50 points or above indicates complete function. An item called alignment has a maximum score of 10 points, which denotes excellent alignment. The maximum score is



Fig. 4. After the closure.

100, which denotes complete absence of symptoms and limitations. Ankle replacement, ankle arthrodesis, ankle instability operations, subtalar arthrodesis, subtalar instability operations, talonavicular arthrodesis, calcaneocuboid arthrodesis, calcaneal osteotomy, calcaneus fracture, talus fracture, and ankle fracture were all described as conditions for which the AOFAS Ankle-Hindfoot Score was to be used in the original publication.

The AOFAS measures are still among the most frequently used tools in clinical trials, and they are still utilized far more often than other validated scales.⁸

The AOFAS score values still provide the greatest comparability across various research since the ankle and hindfoot measurements are both simple to use and comprehend.⁹

Radiographic assessment: Anteroposterior, lateral, and mortise views were ordered in each follow-up visit. Radiographic criteria for normal ankle radiographs were used to interpret the patient's radiographs. Loss of reduction was diagnosed by the presence of any of the following in addition to persistent pain over the fracture site: Medial clear space oblique greater than 4 mm indicating a lateral talar shift, Medial clear space perpendicular greater than 4 mm, Superior clear space greater than 3 mm.¹⁰ (Fig. 5), Loss of the lateral Shenton line, indicating a fibular shortening and loss of height (tip of lateral malleolus forms a complete circle with the lateral process of the talus). (Fig. 5), Another indication of fibular shortening and loss of height is the spike of the fibula pointing to a level higher than the subchondral bone of the tibial plafond and Syndesmotomic width -distance from the medial border of the fibula to the tibial incisura should be less than 5 mm, while tibiofibular overlap is at least 10 mm.

2.4. Statistical analysis

The collected data of the AOFAS score, operative time, and time to a union were obtained during and

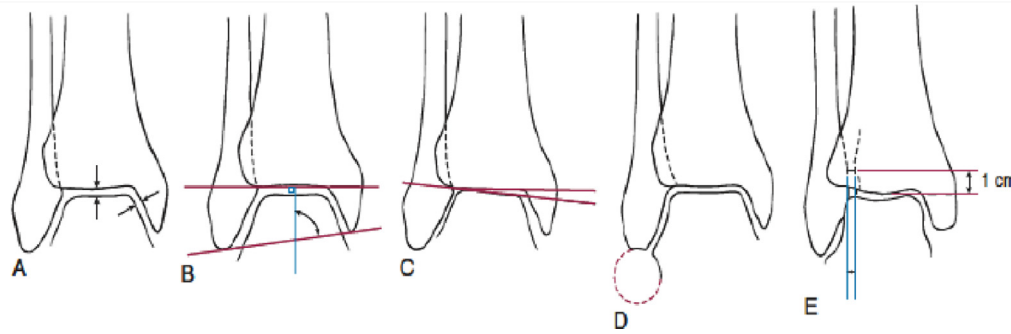


Fig. 5. Radiographic assessment of the ankle joint.

after the application of Anatomical distal fibular plate on lateral malleolus fractures of 20 patients with follow-up to 6 months. The mean of the collected data was analyzed for further analysis (descriptive, comparative, or correlative). Data entry was performed using Microsoft Excel and was statically analyzed using the statistical package for social science (SPSS). Reading of the AOFAS postoperative data at 6 months were compared with age, sex, operative time, time to union, score data at 2 and 4 months, D.M, hypertension (HTN), and smoking to detect significance using paired T-test. Then Mann–Whitney Test was performed to detect the correlation between AOFAS at 6 months and previously mentioned factors. Finally, complication percentages and numbers were compared using age, sex, and predisposing factors of HTN, DM, and Smoking using the Mann–Whitney test and χ^2 tests. Statistical significance was defined as a probability value of ($P < 0.05$).

3. Results

This research was conducted on 20 patients with 20 lateral malleolus fractures (12 with LM only, 7 with pott's, 1 with ankle dislocation) where the age range was 20–68 with a mean age of 42.94, there were 8 men and 12 women. For co-morbidities 8 of the patients were smokers and 4 were diabetic and 8

of them were HTN, all patients radio graphically assessed preoperatively by X-rays, and were classified by the Lauge-Hansen Classification system. The study was done in the orthopedic surgery department, faculty of medicine Al-Azhar university hospitals [Table 4](#).

During this study, the average age ranged from 20 to 68 years with a median of 42.94 years. The median operative time ranged from 45 to 120 min with an average of 82 min (± 23 SD). Time to radiographic union ranged from 6 to 12 weeks with a median of 9 weeks (± 1.7 SD). The average AOFAS scale at 2, 4, and 6 months was 60, 87, and 93 points out of a 100, respectively, with a minimum of 38, 78, and 85 and a maximum of 71, 94, and 100 for 2, 4, and 6 months, respectively [Table 5](#).

This table showed that the mean of Ankle hind foot scale was 94 in male and 91 in females. Mean of time to the union in weeks was 8.5 in male and 10.0 in female [Table 6](#).

This table showed that there was no significant difference between the studied groups regarding Relation between smoking to AOFAS and time to union [Table 7](#).

This table showed that mean of Ankle hind foot scale 6 m was 96 in smoking and 90 in no smoking. Mean of time to the union in weeks was 8.0 in smoking and 10.4 in no smoking [Table 8](#).

This table showed that mean of Ankle hind foot scale 6 m was 88 in DM and 95 in no DM. Mean of

Table 4. Different results of the study.

	Mean	SD	Median	Minimum	Maximum
Age	42.94	12.08	41	20	68
Operative time	82.5	23	75	45	120
Ankle hind foot scale 2 M	60	10	64	38	71
Ankle hind foot scale 4 M	87	5	88	78	94
Ankle hind foot scale 6 M	93	5	95	85	100
Time to union in weeks	9.0	1.7	8.0	6.0	12.0

Table 5. Mann–Whitney test on the relation of sex to American orthopedic foot and ankle society at 6 m and time to union.

Mann -Whitney test	Mean	SD	Median	mini	max
Ankle hind foot scale					
Male	94	5	95	85	100
Female	91	5	93	85	97
Time to the union in weeks					
Male	8.5	1.5	8.0	6.0	12.0
Female	10.0	1.5	10.0	8.0	12.0

Table 6. Relation between smoking to American orthopedic foot and ankle society and time to union are illustrated as follows.

	Mann–Whitney U	Z	P-Value
Ankle hind foot scale 6 m	40.500	–1.457	0.153
Time to the union in weeks	32.00	–2.106	0.052

Table 7. Test on American orthopedic foot and ankle society 6 m and time to union in relation to smoking.

Mann – Whitney test					
	Mean	SD	Median	Minimum	Maximum
Ankle hind foot scale 6 m					
Smoking					
Yes	96	3	95	92	100
No	90	5	89	85	97
Time to the union in weeks					
Smoking					
Yes	8.0	1.1	8.0	6.0	10.0
No	10.4	1.3	10.0	8.0	12.0

Table 8. The relation of diabetes mellitus to American orthopedic foot and ankle society and time to union.

Mann–Whitney Test					
	Mean	SD	Median	Minimum	Maximum
Ankle hind foot scale 6 m					
DM					
YES	88	4	87	85	94
No	95	3	95	89	100
Time to the union in weeks					
DM					
Yes	11.2	1.1	12.0	10.0	12.0
No	8.4	1.3	8.0	6.0	10.0

DM, Diabetes Miletus.

time to the union in weeks was 11.2 in DM and 8.4 in no DM [Table 9](#).

During this study, significant values were found between age, operative time, ankle hind food scale at 2 months, ankle hindfoot scale at 4 months, and time to union in relation to Ankle hind foot scale at 6 months. Although the relationship between the operative time and the AOFAS score at 6 months is

Table 9. Relation between hypertension to American orthopedic foot and ankle society and time to union at 6 m.

Mann–Whitney test					
	Mean	SD	Median	Minimum	Maximum
Ankle hind foot scale 6 m					
HTN					
YES	88	4	87	85	94
No	96	3	95	92	100
Time to union in weeks					
HTN					
Yes	10.8	1.0	10.0	10.0	12.0
No	8.1	1.1	8.0	6.0	10.0

Table 10. Incidence of complication.

	Technique of fixation	
	Anatomical Plate (n = 20)	
	Count	%
Superficial infection		
Yes	4	20.0
No	16	80.0
Deep infection		
Yes	2	10.0
No	18	90.0
Malunion		
Yes	0	5.0
No	20	95.0
Hardware Prominence		
Yes	5	25.0
No	15	75.0

Table 11. Sagittal motion flexion and extension.

Sagittal motion flexion plus extension	Technique of fixation	
	Anatomical (n = 20)	Plate
	Count	%
Normal or mild restriction	18	90.0
Moderate restriction	2	10.0
Severe restriction	0	0.0

more logically due to mere coincidence. The correlations are described in the following table. As for sex distribution, no actual significance was found between AOFAS at 6 m or time to union, and the sex of the patient's results are illustrated in [Table 10](#).

This table showed that in fixation of anatomical distal fibular plate there were four patients who experienced superficial wound infection. Only two patients was complicated with deep wound infection. No patient showed malunion of lateral malleolar fracture. Five out of 20 patients who received an anatomical lateral plate complained of feeling the plates and the screws, despite the fact that fibular plating is still a common treatment for lateral malleolar fractures [Table 11](#).

And about range of motion sagittal motion flexion plus extension was graded as normal or mild restriction in 18 (90 %) patients while no patients with severe restriction.

Table 12. Hind foot motion about inversion and eversion.

Hindfoot motion inversion plus eversion	Technique of fixation	
	Lateral Plate (n = 20)	
	Count	%
Normal or mild restriction	18	90.0
Moderate restriction	2	10.0
Severe restriction	0	0.0



Fig. 6. Lateral malleolus fracture AP, lateral and mortise.



Fig. 7. Lateral malleolus fracture AP, lateral and mortise.

Hindfoot motion inversion plus eversion was graded normal or mild restriction in 18 (90 %) patients while moderate restriction in two (10 %) patients, no patients with severe restriction [Table 12](#).

Hindfoot motion inversion plus eversion was graded normal or mild restriction in 18 (90 %) patients while moderate restriction in two (10 %) patients, no patients with severe restriction.

There were no significant relationship between any of these complication and the predisposing factors of DM, HTN, age, and sex of patient.

4. Case presentation

4.1. Case (1)

A 43 years old female patient, DM, had a twisting injury, sustained a closed left ankle fracture, supination external rotation type according to Lauge-Hansen classification, type B according to Danis-Weber classification. He presented to the emergency department on the same day of injury.

The patient is HTN, DM. The patient was put in a slab to minimize the edema and pain and then operated upon on the 5th day after the injury [Figs. 6–9](#).



Fig. 8. Postoperative fixation of lateral malleolus with anatomical distal fibular plate.



Fig. 9. Follow-up of case 1 after 6 months.



Fig. 10. Preoperative radiography of lateral malleolus fracture AP and lateral.

4.2. Case (2)

A 65 years old female patient, DM and HTN, had a twisting injury, sustained a closed left ankle

fracture, pronation external rotation type according to Lauge-Hansen classification, type C according to Danis-Weber classification. She presented to the emergency department on the same day of injury.

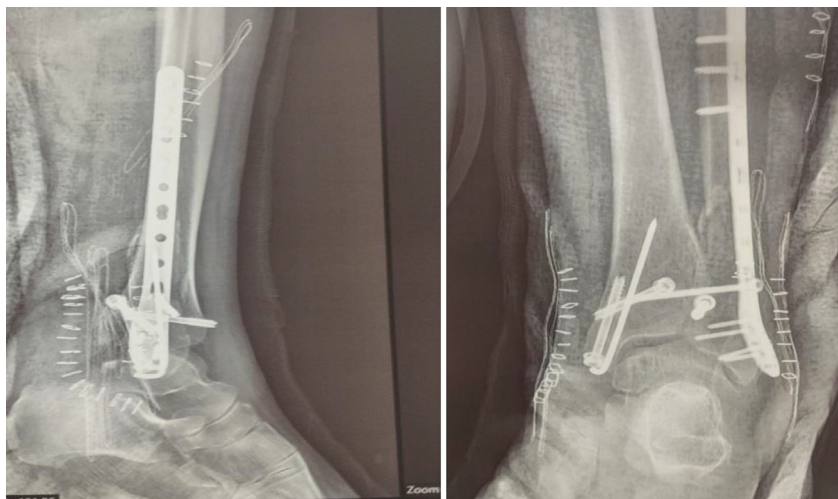


Fig. 11. Postoperative radiography AP and lateral.



Fig. 12. Follow-up radiography after 6 months.

The patient was put in a slab to minimize the edema and pain and then operated upon on the 5th day after the injury Figs. 10–12.

5. Discussion

The surgical stabilization of lateral malleolar fractures is still debatable. In order to prevent the long-term effects of symptomatic nonunion and posttraumatic osteoarthritis, anatomic reduction and internal fixation are increasingly employed to treat lateral malleolar fractures.¹¹

The altered physiologic motion of the talus caused by ankle joint instability due to anatomical compromise decreases articular congruity and enhances contact pressure, which presumably raises the risk of degenerative joint disease.¹²

However, inconsistent findings have been found in biomechanical investigations examining the relative contributions of the medial and lateral components.

A biomechanical study by Annie Nguyentat and colleagues for evaluation of anatomical plate and its stability. The fractures were fixed by anatomical locked plate and underwent torsional and axial cyclic loading followed by torsional loading failure. It was discovered that 72 % of the native bone strength was given by the plate. The anatomical plate for distal fibular fracture offers stable fixation, despite the fact that this was statistically unimportant. Therefore, early rehabilitation may begin without fear of diminution or loss of function. In this study, 20 patients with lateral malleolus fracture was fixed by open reduction and internal fixation with anatomical distal fibular plate.¹³

Mario Herera-Perez et al. this study Between 2011 and 2014, 17 patients over the age of 64 received surgery for osteoporotic distal fibula fractures. were fixed with a locking plate to stabilize them. At 4, 8,

12, 26, and 52 weeks, follow-up was conducted. The AOFAS Ankle-Hindfoot Score and radiographic criteria for consolidation were used to evaluate the results. AOFAS scores at 6 and 12 months were shown, along with the average time to union and scores for each of the specific categories: function, pain, mobility, and alignment. The interval before beginning to bear any weight was considerably (4.69 ± 2.63). The most frequent side effects were superficial infection and wound dehiscence. In our study on 20 patients with mean age ± 42.94 the time of union varies from 6 to 12 weeks, with average period of follow-up was 24.5 weeks (6–12 months).¹⁴

René Aigner and colleagues a retrospective case-control study, locking plates were used to treat 70 patients. Early results and locking plate complications rates. Patients in this research who received locking plates were older and had more severe fracture patterns. These individuals also had more serious comorbidities. Therefore, we draw the conclusion that pre-contoured locking plates are a suitable choice for treating severe ankle fractures in patients with pertinent co-morbidities. To demonstrate the superiority of locking plates for the treatment of elderly ankle fractures, prospective randomized studies are required.¹⁵

Schepers and colleagues performed retrospective clinical research the incidence of complications after locking plate surgeries. Seven individuals out of the 40 who used the locking plate had wound problems. Because the features of no compression on the periosteum might enhance the subcutaneous volume of the fracture site, these findings were believable.¹⁶

5.1. Limitations of study

- (1) The limited number of patients enrolled in the study and longer follow-up periods are needed.
- (2) Anatomical distal fibular plates are expensive.

- (3) Lacking scientific rigor and providing little basis for generalization of results to the wider population.

5.2. Conclusion

The use of anatomical distal fibular plate in lateral malleolar fracture give stability, this will achieve by the contour of the plate, its thickness and the distribution of the holes. Also provide good functional outcomes as regard to medical outcomes study (MOS) and AFOAS.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article.

Conflicts of interest

The authors declared that there were no conflicts of interest.

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