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ORIGINAL ARTICLE

Distal Fibula Fracture Fixation: Comparison Between the One-third Tubular Plate and the Anatomically Contoured Locking Plate

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Abstract

Background: **Ankle fractures are very common fractures. There are several techniques and implants to treat fibular fractures, including open reduction and internal fixation (ORIF) of the lateral malleolus at the distal fibula.**

Aim: **This study compares anatomically locked distal fibular plate internal fixation and open reduction of lateral malleolus fracture outcomes.**

Patients and methods: **This study included 20 patients with lateral malleolar fractures according to Weber classification Weber A and Weber B, who presented at the Emergency of Al-Hussain Hospital and Al Sahel Teaching Hospital.**

Results: **The mean sagittal and hindfoot motion was satisfying in both groups. The mean time for fracture healing is slightly longer in group one than in group two. The mean time from injury to surgery is slightly longer in group one (7.8) than group two (7 weeks). No patients needed implant removal in either groups.**

Conclusion: **In terms of torsional and external rotational loads, this study shows that the lateral anatomical contoured distal fibula locking plate is comparable to a one-third tubular plate. Anatomically designed distal fibula locking plates with improved sites of fixation in the distal region may offer surgeons a more dependable choice in the event of unstable, osteoporotic distal fibula fractures.**

Keywords: Anatomical contoured locking plate, Distal fibula, Fracture fixation, Tubular plate

1. Introduction

Ankle fractures are very common fractures. Several techniques and implants were found to treat fibular fractures, including open reduction and internal fixation (ORIF) of the lateral malleolus at the distal fibula.[1]

Although fibula ORIF postoperative problems are uncommon, they do occur. Such problems include ankle arthrosis and/or arthritis during the intermediate to long term at a rate of 10% and superficial or deep infection with a frequency of 2%. Implant failure and discomfort are two additional postoperative complications.[2]

Anatomically locked fibular plates offer a way to increase stability, especially when osteopenia is severe. In many cases, prolonged immobilization is required regardless of the type of management used to stop the progression of neuropathy.[3]

Numerous challenging fractures can be resolved by the new generation of anatomically locked plates. This LCP distal fibula locked plate is a component of the locking compression plate system, which combines conventional plating methods with locking screw technology. The plates come in titanium and stainless steel. The plates have an anatomical shape and contour along the fibular shaft and distally. The LCP plate shaft's combi holes combine a hole for a dynamic compression unit and a hole for a locking screw.[3]

Depending on how close the fibular fracture is to the syndesmotic ligaments of the ankle, it is classified as a Danis–Weber-Type A, B, or a C fracture.

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Particularly, Danis–Weber B fractures may extend distally to the position of the talar dome from the position of the syndesmosis. Weber B fractures are also known as OTA 44B lateral malleolus fractures under the Orthopedic Trauma Association (OTA) categorization system.[4]

In the past, the implant for fibular fixation was a one-third tubular plate that was flat and did not match the shape of the lateral side of the distal fibula. Alternative fixation techniques include using biodegradable plates and screws, anatomically shaped lateral malleolar locking plates, and interfragmentary lag screws alone.[5]

ORIF has much better results than nonoperative care, according to numerous studies. To help treat osteoporotic bone, alternative surgical techniques include the use of intramedullary fibular nails, Kirshner wire cages, tibia pro-fibula screws, posterolateral fibular plates, and Kirshner plates. Nylon cavity plugs are a type of device that has been created to boost the purchase and salvage of stripped screws in osteoporotic bones.[5]

This biomechanical study will add to what is already known about distal fibular fixation by providing more technical evidence that these plates should be used. Previous literature says that stainless steel plates fail when they flex plastically because of a force that is greater than the yield strengths of the different parts of the material.[6]

The goal of this study was to compare the outcomes of open reduction and internal fixation (ORIF) for lateral malleolus fractures when an anatomically distal fibular locked plate and a third tubular plate were used.

2. Patients and methods

This study included 20 patients who presented at **the Emergency of Al-Hussain Hospital and Al Sahel Teaching Hospital.**

2.1. Randomization

We randomly allocated patients to either one-third tubular plate fixation group or the distal anatomical fibular plate fixation group in a 1 : 1 ratio.

2.2. Data processing

The local research ethics committee's ethical permission was acquired. Standard consent was taken from all patients.

2.3. Intervention

Patients were split randomly into two groups based on the fixation techniques: **Group (A)** 10 patients received treatment by open reduction and one-third tubular plate fixation. **Group (B)** 10 patients received treatment by open reduction and distal fibular anatomical locked plate fixation.

The follow-up period was 12 weeks at least, and the average follow-up period was 16 weeks.

2.4. Inclusion criteria

We included both sexes, aged more than 18 years, with lateral malleolar fracture according to Weber classification Weber A and Weber B (isolated or associated with medial malleolar fracture).

2.5. Exclusion criteria

Patients with previous fractures of the involved limb, pediatric fracture, open fracture, pathological fractures, neurological disorders, or vascular injuries that might prevent healing or affect functional recovery (e.g. Charcot joint) **and** patients unfit for surgery.

We collected all personal data from all patients in both groups: (name, date of birth, age, gender, occupation, residence, telephone number, and specific behaviors that are crucial to health) and the cause of trauma at patient entry.

Clinical data, examination, radiological assessment, and primary management: The time of union was assessed. At each visit, all fractures were assessed using three views of the ankle (anteroposterior, mortis, and lateral) and clinically utilizing the American Orthopedic Foot and Ankle Society (AOFAS), Olerud and Molander Score, Ankle-Hindfoot Score, and radiologically. For all patients, skin condition was recorded. Patients had a clinical examination to assess the state of their soft tissues, and lateral, mortise, and anteroposterior X-rays were taken.

Twelve patients had a bad skin condition in the form of edema and ecchymosis. The injured leg was raised till the time of operation while the patients were placed on a back slab.

Clinical evaluation: General: Management according to **Advanced Trauma Life** Support **(ATLS)** protocol ABCDE: evaluation with the goal of treating first what kills first: (A) stabilization of the C-spine and airway, (B) breathing, (C) circulation, (D) disability, and (E) environment and exposure. We gave attention to other systems injury and associated fractures. **Local:** Tenderness, range of motion,

edema, skin condition, and a neurovascular examination were all conducted as part of the standard ankle evaluation. There was a check for any connected injuries.

Investigations: Radiology: All patients were assessed by plain X-rays: A-P, lateral and mortise views of the ankle. **Laboratory:** Routine preoperative laboratory tests include total blood count, renal, hepatic, random blood sugar, and coagulation profile.

2.6. Time till surgery

Surgery was performed after 2–9 days (average: 5 days), waiting for edema to subside.

2.7. Treatment regimen and technique

2.7.1. Group 1 (one-third tubular plate fixation)

On a typical radiolucent orthopedic table with image intensifier guiding, patients were operated on while under spinal anesthesia. With the induction of anesthesia, 1 g of Cefotaxime (Claforan TM) was administered, and the antibiotic was maintained for 2–3 days afterwards.

2.8. Operative details

2.8.1. Patient positioning

On the operating table, the patients were supine. During the procedure on the lateral malleolus, a sandbag was placed beneath the gluteal area to internally twist the leg. Tourniquet: A pneumatic tourniquet was used in every instance.

2.8.2. Implant used

One-third tubular plate was utilized in 10 patients. We put the plate directly lateral but we pre-contoured the plate before we put it.

2.8.3. Incision and plate insertion

To avoid damaging the superficial peroneal nerve, which is often seen at this level, we made a longitudinal incision across the lateral malleolus focused on the fracture. We then performed blunt dissection through the subcutaneous fat (Fig. 1).

2.8.4. Open fibula reduction

The helper provides traction to draw the distal fragment out and internally rotate it. Foot inversion/internal rotation: The anatomical reduction can be maintained by applying a pointed reduction clamp obliquely across the fracture or by placing the plate directly and holding it with a plate holder.

Fluoroscopically inspecting normal radiographic characteristics determines reduction. A lag screw crosses the fracture orthogonally. A 1/3 tubular plate is pre-countered to the fibula and applied as a neutralization plate with at least three cortical screws above and three cancellous screws below the fracture. The metaphyseal screws should be placed in a triangular configuration to prevent the distal cancellous screws from entering the joint.

(1) Group 1: lateral plate fixation took 45 ± 9 min.
(2) **Group 2 (distal fibular anatomical locked plate):** Spinal anesthesia patients were operated on a radiolucent orthopedic table with image intensifier guidance. One gram of Cefotaxime (Claforan Tm) was given during anesthesia and continued for 2–3 days.

Patients supine on the operation table. A sandbag under the gluteal area internally twisted the leg during the lateral malleolus surgery.

2.8.5. Tourniquet

Not needed. It was only needed with open medial malleolar fracture fixation (Fig. 2).

Fig. 1. Skin incision at the beginning and at the end of the operation.

Fig. 2. Superficial peroneal nerve in the anterior flap should be identified and protected.

2.8.6. Implant

Lateral distal fibula anatomical locking plate in 10 patients.

2.8.7. Cut and plate

A longitudinal lateral incision addressed the lateral face of the ankle, and an incision was carried down to the bone without dissection on the lateral side of the ankle, protecting anteriorly, particularly in the proximal region, branches of the superficial peroneal nerve.

The plate may be used to aid and direct the reduction of comminuted fracture patterns. This can be crucial when using a bridging procedure on comminuted fractures. To help with the interim maintenance of the reduction and for plate implantation, Kirschner wires may be inserted through the proximal and distal ends of the plate. Depending on how the fracture is configured, options for preserving the reductions include separate lag screws, lag screws through the plate, and locking screws through the plate. There is no interfragmentary compression provided by locking screws (Fig. 3).

2.8.8. Operative timing

The mean operative time was (23 ± 6) min.

Postoperative management for two groups: IV antibiotics (Cefotaxime) was administered for 2–3 days postoperatively, followed by oral antibiotics (Augmentin and Flagyl‘ Tm) for 7 days. The hospital stay ranged from 2 to 3 days postoperatively. The patients were put in a below-knee slab for 4 weeks.

2.8.9. Follow-up for two groups

Immediately after surgery, plain films were used to assess the decrease; first follow-up was done after 2 weeks to check wound and suture removal.

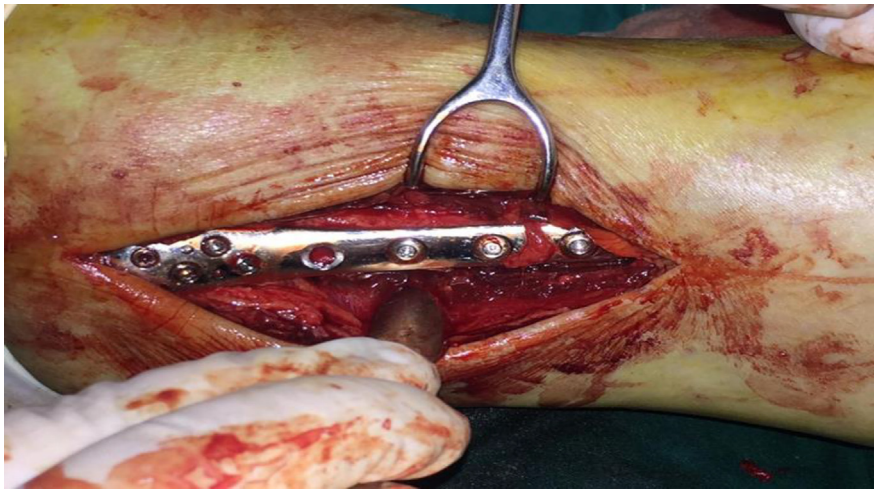

Fig. 3. Anatomical distal fibular locked plate intra-operative.

Table 1. Demographic data of each group.

	Group 1		Group 2	
	Event	Percentage	Event	Percentage
Age (mean and SD)	43.4	9.4	37.9	11.93
Female	3	30	7	70
Male	7	70	3	30
BMI (mean and SD)	21.4	5	18.5	4.4
Nonsmoker	8	80	7	70
Smoker	2	20	3	30
DM history	4	40	6	60

Regular visits were done every (3–4) week, and plain radiographs were obtained in each visit. The below-knee slab for the two groups was removed after 4 weeks. The clinical union was assessed by clinical examination after the removal of the back-slab. The early functional outcome and pain were assessed by the AOFAS score and Modified olerud molander score at (3–6) months. The patients in two groups were instructed to start range of motion in the form of ankle dorsiflexion and plantar flexion, in addition to foot eversion and inversion, then partial weight-bearing when the bone union is confirmed clinically and radiologically. During follow–up, there are two patients who were missed in group 1 at 3 months, and two patients who were missed in group 2 at 4 months follow-up.

3. Results

We included 10 patients in each group. Age distribution in both groups: the median is 44.5 and 36.5 in both groups, respectively, with minimum age at 30 and 20 and maximum age at 55 and 55. Lastly, the mean age group at 43.4, 37.9 and SD is 9.4 and 11.93, respectively, in both groups. This means that group 2 patients were younger than those in group 1. In all, 4 and 6 patients had a history of DM in groups 1 and 2, respectively (Table 1).

Results showed that most of both groups developed good scores by 60% in group 1 and 50% in group 2, which means both techniques have nearly equal results (Fig. 4). Our data showed that most of both groups developed good scores by 50% in both groups, which means that both techniques have nearly equal results (Fig. 5).

The mean sagittal motion is good in both groups. The mean hindfoot motion is good in both groups. The mean time for fracture healing is slightly longer in group 1 than in group 2. The mean time from injury to surgery is slightly longer in group 1 (7.8) than in group 2 (7 weeks). The mean number of patients who need to implant removal is less than one in both groups (Table 2). Complication rate results showed that the infection occurred in one patient in group 1 and 2 patients in group 2, while wound dehiscence occurs in one patient in group 1 (Table 3).

In this study, subgroup analysis showed an insignificant correlation between patients' age and the final result. The mean tourniquet time is greater in group 2 than in group 1, which indicates that the contorted plate takes longer to apply than the locking plate. As for operational details, the mean operative time is marginally longer in group 1. In our locking plate group, lag screws were used substantially less often. According to McLennan and Ungersma's criterion, radiographic assessment revealed that 50% of both groups had obtained excellent scores, which is the majority in both groups. Thus, the outcomes of the two approaches are essentially comparable. The anatomical distal fibular locked plate significantly provides no torque to failure. Construct stiffness and the strength of the plate make it more suitable for the fixation of severe osteoporotic and comminuted fractures as it provides a high functional level and patient satisfaction.

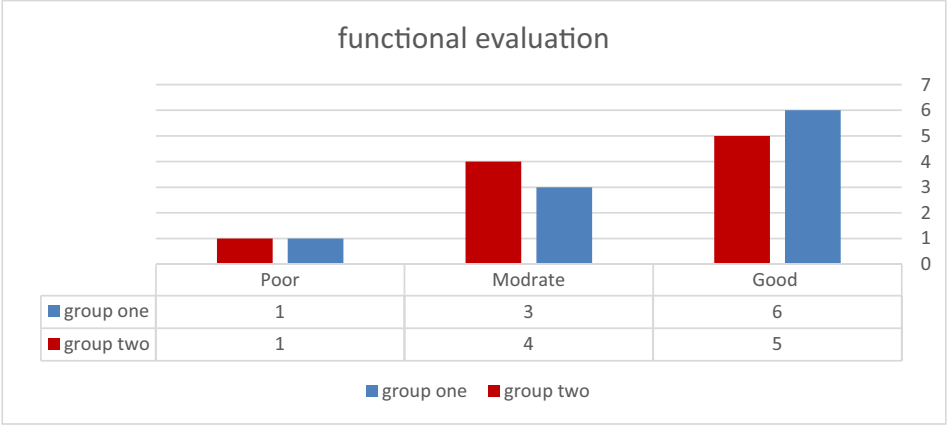

Fig. 4. Functional and radiographic rating according to McLennan and Ungersma's criteria.

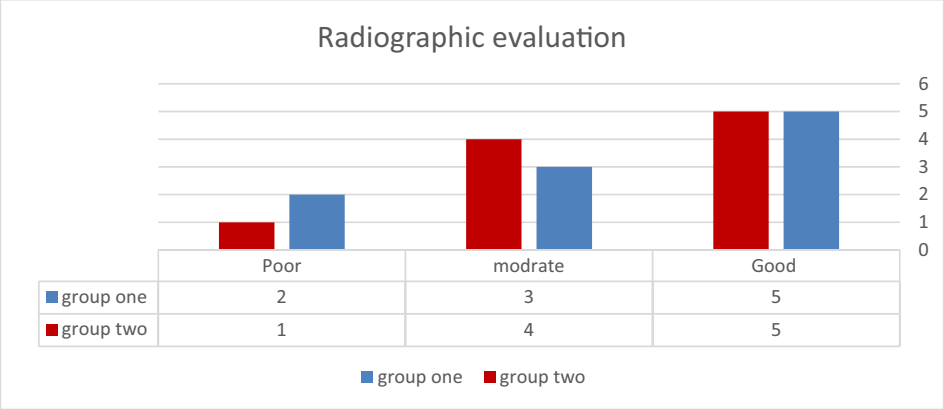

Fig. 5. Radiographic rating according to McLennan and Ungersma's criteria.

Table 2. Functional outcome parameters in both groups in numbers.

Functional outcome	Group one	Group two
Sagittal motion	2.7	2.4
Hindfoot motion	2.5	2.888889
Time to fracture healing (weeks)	8.9	8
Time from injury to surgery (days)	7.8	7
Need for implant removal n	0.4	0.3

4. Case (1)

4.1. History

Female of age 32 years, supination external rotation type according to Lauge–Hansen categorization, type B according to Danis–Weber classification, twisting injury, and closed left ankle fracture. On the day of the accident, she went to the emergency room. On the fourth day after the incident, the patient had surgery after being placed on a slab to lessen edema and discomfort.

4.2. Radiology

Fig. 6.

4.3. Treatment

The medial malleolus was reduced by K-wires and a tension band. Through an 8.5 cm skin incision, open reduction of the fracture was done with the aid of a reduction clamp and fixed with a lateral (tubular one-third) plate (Fig. 7).

Table 3. Complication in both groups.

Complications	Group one	Group two
Infections	1	2
Wound dehiscence	1	0

4.4. Follow-up

Immobilization was prolonged for 4 weeks. Partial weight-bearing was allowed after 8 weeks, and full weight-bearing was allowed after full radiological and clinical union, which occurred at 11 weeks (Figure 57). The patient was followed up for 6 months. At follow-up, the AOFAS and OMAS were excellent at 90%. The patient had no pain and returned to his pre-injury job (Figs. 8 and 9).

5. Case (2)

5.1. History

A 61-year-old housewife had a left lateral malleolus fracture after falling and twisting her ankle. She had no significant medical or surgical history; x-rays were obtained in the ER Fig. 31(a). The patient was sent to the operating room 2 days post-trauma for ORIF using an anatomical distal fibular locked plate for the lateral malleolus. The AOFAS score after 6 months follow-up was 100 (excellent) (Figures 00 b,c). The ankle range of motion after 6 months is shown in Fig. 10.

Radiology.

5.2. Treatment

The lateral maleolus was fixed by an anatomical distal fibular locked plate (Figs. 11–13).

Follow up.

6. Discussion

Ankle fracture fixation methods are an issue of interest. The soft tissue, which is often quite brittle in this anatomical region, is sometimes extensively comminuted in distal fibula fractures in the elderly, particularly in those over 80.

Fig. 6. Pre-operative AP & Lat. view radiograph of the Left Ankle Joint.

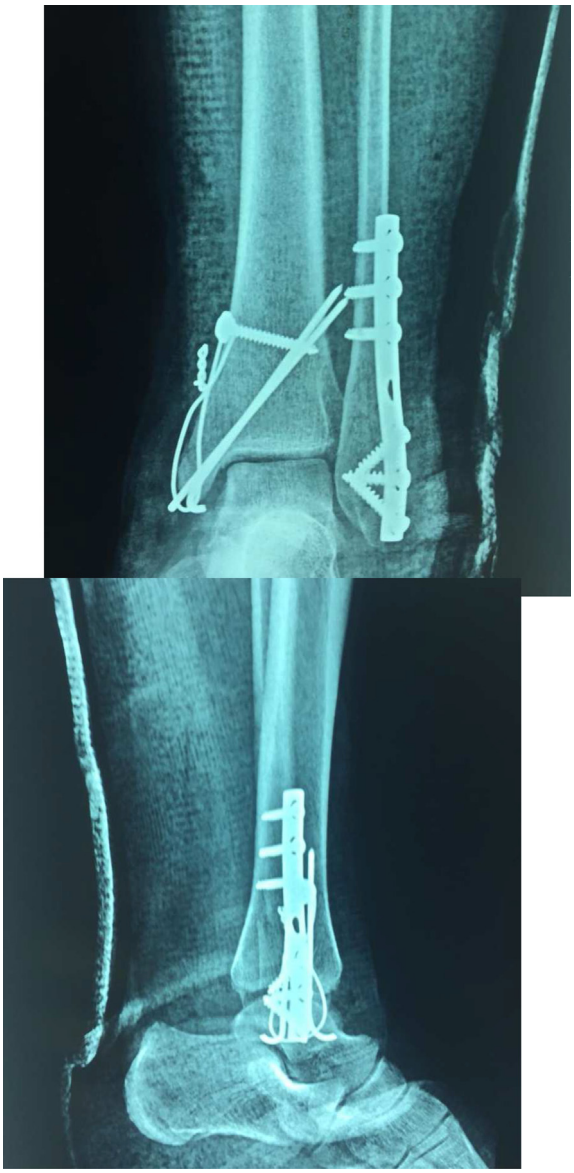

Fig. 7. Post-operative AP & Lat. view of the Left Ankle Joint.

Supination-external rotation ankle fractures account for 40–75% of all ankle fractures, and surgical intervention has been found to be preferable to conservative care in the treatment of elderly patients with unstable ankle fractures.[6,7] If there is substantial fibular or talar displacement, fixing is necessary. The one-third tubular plate, hook plate, and Rush-rod are the three most commonly used techniques for internal fixation of the fractured lateral malleolus.

We did not examine the variations in bone mineral density in our patients to compare them to our findings on the kind of fixation. But since both

Fig. 8. Follow-up X-rays after 3 months.

Fig. 9. Rang of motion of the Left Ankle Joint.

groups of patients were similar, we decided that this theoretical gain is not clinically important.

This supports the research results presented by White et al.[8] Employing cadavers to compare locking and non-locking, one-third tubular plates in comminuted Weber Type C fractures, they also came to the conclusion that both implant types are biomechanically similar.

Danis–Weber Type B fractures in simulation, Eckel et al.[9] Comparisons were done between a standard one-third tubular plate with an interfragmentary screw, a low profile locking plate with an interfragmentary screw, a conventional locking plate with an interfragmentary screw, and a specially constructed plate with an auto-compression system. They discovered that these fixation mechanisms did not vary biomechanically from one another.

This research compared the results of ORIF for comminuted lateral malleolus fractures with an anatomically locked distal fibular plate to those with one-third plates. Two groups of patients, one with a third tubular plate (group I; $n = 10$), and the other with an anatomical distal fibula locking plate (group II; $n = 10$), were created. In terms of demographic data, the median age in groups one and two was 44.5 and 36.5, respectively, with a minimum age of 30 and a maximum age of 55. The median age group was 43.4 9.4 and 37.9 11.9, respectively, in both groups. This means that group two patients were younger than group one.

Yeo et al. reported a median age of 46 years, ranging from 16 to 73 years. Hwang S et al. were 71.2 years old on average, with a range of 65–85 years.[10]

In the present study, there was an insignificant correlation between the patients' age and the final result. This is similar to the results of Yeo et al.[10] studies.

As regards post-operative follow-up Functional and radiographic rating according to McLennan and

Fig. 10. Preoperative AP and lateral radiographs.

Ungersma's standards showed that most of both groups developed good scores, with 60% in group one and 40% in group two, which means that both techniques produce nearly equal results. Both groups had similar functional outcome parameters. The mean sagittal motion is good in both groups. The mean hindfoot motion is good in both groups. The mean time to fracture healing is slightly longer in group one than in group two. The mean time from injury to surgery is slightly longer in Group 1

Fig. 11. And lateral radiographs after 6 weeks.

Fig. 12. AP and lateral radiographs at 6 months postoperatively.

(7.8) than Group 2 (7 weeks). The mean number of patients needing implant removal is less than one in both groups.

When compared to the other research groups, the time spent weight-bearing was much shorter in the locking plate group. This was established based on the patient's reported discomfort, range of motion, and radiological findings by the follow-up surgeon; this conclusion should be read cautiously since delay to weight bearing does not indicate hardware failure.[11]

As per McLennan and Ungersma's standards, the majority of both groups developed good scores by 50% in both groups, which means that both techniques produce nearly equal results.

As regarding the complication rate, it showed that one patient in group one had an infection, compared to two patients in group two, and one patient in group one experienced a wound dehiscence.

Fig. 13. Range of motion at 6 months.

All failures occurred at the distal screw cluster, despite the fact that we did not see any defects in the locking plate or group at the position of the lag screw. This makes us think that putting in the lag screw didn't change the locking plate's stiffness all that much.

Few investigations have compared one-third plating versus locked plating. The anatomically locked plate is biomechanically superior to a one-third tubular locking plate in osteoporotic bone, according to recent cadaver research by Minihane et al.[6]

In a separate cadaver study, Schaffer and Manoli found that the one-third tubular locking plate was better than the traditional lateral plating method from a biomechanical point of view.[12]

The strength of the locked plating was found to be independent of the mineral density of the bone. However, there was no statistically significant difference between the two designs.

We estimated the torque to failure of these specimens to be 5 Nm since the early failures were most likely caused by the threshold in those specimens being near the cycle loading torque. We also measured the energy absorbed to further compare all specimens, and we discovered that the lateral specimens absorbed more energy. The possible weakening of the bone due to the greater use of distal locking screws is a possible drawback. The screw creates a fracture-prone area by adding additional bony defects to already weak osteoporotic bone.

Using matched pairs of people with osteoporosis, we compare two common types of fixation used in clinical practice. However, our research may not have been able to replicate the small areas of comminution that are often found in these fractures.

Jason Bariteau and his colleagues found that locked plating made comminuted fractures significantly more stable. For comminuted SER ankle fractures, they decided that a locking plate is better than a regular one-third tubular plate.[13]

This work does have certain limitations. Overall, there weren't very many patients. While the quality of life was not assessed in this study, prior research has shown that there are no substantial differences between patients managed with locking and non-locking plates. We recommend other researchers estimate the quality of life-related scores with larger sample sizes in each group.

In conclusion, this study shows that under torsional and external rotational loads, the lateral anatomically contoured distal fibula locking plate is comparable to a one-third tubular plate. Anatomically shaped distal fibula locking plates with better

fixation points in the distal part may give surgeons a better way to treat unstable distal fibula fractures caused by osteoporosis.

6.1. Conclusion

This study showed that one-third of tubular plates, which are less expensive than anatomical distal fibula locking plates, provide equivalent clinical and radiological results and should be taken into account when treating displaced non-comminuted lateral malleolar fractures. In the case of unstable, osteoporotic distal fibula fractures, anatomically shaped distal fibula locking plates with enhanced sites of fixation in the distal section may provide surgeons with a more reliable option. The one-third tubular plates nevertheless provide good fastening and are an alternative. Given that locking plates are much more costly than non-locking and one-third of tubular plates, this might have severe economic ramifications. We suggest expanding the sample sizes in both categories and including additional quality-of-life-related ratings.

Authorship

All authors have a substantial contribution to the article.

Disclosure

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

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Conflicts of interest

No conflicts of interest.

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