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A STUDY OF THE FUNCTIONAL OUTCOME OF DIFFERENT COMBINATIONS OF SCREWS, PLATING AND K-WIRING IN THE SURGICAL TREATMENT FOR BIMALLEOLAR ANKLE FRACTURE IN ADULTS

Orthopaedics

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ABSTRACT

Background: Ankle fractures, 9% of adult fractures, are influenced by injury extent, alignment, cartilage damage, and medical disorders. Magnetic resonance imaging aids diagnosis and treatment. Malleolar fractures require precise realignment and secure internal fixation. The study evaluates the functional outcomes of different screw, plating, and K-wire combinations in adult surgical treatment for bimalleolar ankle fractures, including union time, movement range, and functional scoring system. **Methods:** Total 102 patients with recently diagnosed bimalleolar fractures. The study was an interventional/experimental randomized controlled study with a 6-month duration. Patients aged 18 or older were included, and they underwent preoperative imaging, postoperative care, and functional outcomes were evaluated using the American Orthopaedic Foot & Ankle Society score. **Results:** Total 102 adult patients and divided them into three treatment groups. The age distribution was uniform, with no significant differences. The gender distribution was similar, with Group I having 70.5% males, Group II having 61.7%, and Group III having 55.9%. The fracture side distribution was significant, with 64.7% of patients in Group III having right-side fractures. The mode of injury was consistent across groups, with slipping or stumbling being the most common. Functional outcomes were significantly different, with 61.7% of Group I rated as 'Excellent'. **Conclusion:** The study reveals that surgical techniques for treating bimalleolar ankle fractures significantly impact clinical outcomes, radiological union times, and full weight-bearing time. Group I, using medial malleolar screws and lateral locking compression plates, showed superior functional outcomes. The study emphasizes the need for personalized approaches based on individual patient demographics, fracture characteristics, and recovery timelines.

KEYWORDS

Bimalleolar ankle fracture, K-wiring, surgical treatment, screws, plating, AOFAS score, fracture fixation, functional outcome, postoperative surgery.

INTRODUCTION

Ankle fractures are a significant issue in adults, accounting for approximately 9% of all fractures.[1,2] These injuries occur within the joint and can be influenced by factors such as the extent of the injury, proper alignment of fractured bones, additional damage to cartilage and ligaments, post-operative rehabilitation programs, and existing medical disorders. The ankle is the most frequently damaged joint in the body, yet it receives the least effective treatment.[3,4]

Ankle injuries are significant due to the transmission of body weight and the dependence of movement on joint stability. Magnetic resonance imaging is currently valuable for identifying ligamentous injuries and facilitating the treatment of fractures.[5] Malleolar fractures primarily affect either the lateral or medial malleolus and often involve other areas of the ankle. The occurrence of malleolar fractures is determined by two factors: the posture of the foot during the injury (either supination or pronation) and the deforming force applied, which may be external rotation, abduction, or adduction.[6,7]

Ankle fractures account for 9% of all fractures and comprise a substantial percentage of the trauma workload. The yearly occurrence ranges from 107 to 184 per 100,000 individuals, with approximately 2% of these fractures being open fractures. Ankle fractures typically impact young males and older females, with alcohol and slick surfaces being implicated in approximately one-third of the instances. Twisting injuries and falls are the primary culprits behind ankle fractures, with sports injuries following closely after. Fractures in middle aged and older persons are linked to diabetes mellitus and obesity.[8-10]

The majority of fractures occur in conjunction with ligament injuries, and the specific characteristics of the force exerted on the ankle joints determine both the type and direction of the fracture.[11]

Malleolar fractures are a common type of fracture in orthopaedic traumatology, requiring precise realignment and secure internal fixation. Inaccurate reduction can lead to post-traumatic pain limitation or the development of osteoarthritis. The ankle joint is inherently unstable due to its anatomical position, making it more susceptible to damage during everyday activities. Management of these fractures is complex and demanding, with insufficient and incorrect treatment leading to enduring orthopaedic consequences and impairment.[12,13]

The operative procedure for malleolar fractures can be either closed reduction or open reduction with internal fixation (ORIF). The conservative approach of closed reduction is effective in treating stable injuries, but unstable, displaced, and open fractures require open reduction and internal fixation (ORIF). The literature has extensively proven the superiority of OIF versus closed therapy.[14]

MRI is valuable for accurately identifying ligament injuries, and it is important to consider restoring these components when treating fractures. To prevent problems, it is essential to achieve anatomical reduction by open techniques and internal fixation for bimalleolar ankle fractures. The introduction of A.O principles of care has led to improved outcomes for bimalleolar ankle fractures, emphasizing anatomical reduction, stable internal fixation, restoring the complete length of the fibula, and initiating early pain-free mobilization.[15] While surgical surgery is often more efficacious in treating unstable ankle fractures, stable fractures can be effectively maintained using conservative methods. However, research on the varying functional outcomes associated with different combinations of screws, plating, and K-wiring in surgical interventions for ankle fractures is limited. This study aims to address this gap by comparing the functional results of various combinations of screws, plating, and K-wiring in the surgical management of bimalleolar ankle fractures in adult patients.

The study aims to assess the functional outcomes of various combinations of screws, plating, and K-wire in surgical treatment for bimalleolar ankle fractures in adults, including time required for union, range of movements, and functional scoring system (Baird and Jackson) for pain, ankle stability, walking, running, and work.

Methods

This prospective Randomized control study at Department of Orthopaedics, Santosh Medical College and Hospital in Ghaziabad.

Total 102 patients who present with recently diagnosed bimalleolar fractures. The study is an interventional/experimental (prospective) randomized controlled study, with a 6-month duration. The study includes patients aged 18 years or older, either sex, with a bimalleolar fracture of any ankle joint, fit for surgery, and eager to participate. The study was follow up for six months, collecting a thorough history of the injury, its mechanism, and any relevant past or personal history. The patient underwent preoperative imaging, including X-rays and CT scans, under sterile conditions by experienced orthopedic surgeons. Postoperative care included immobilization, pain management, and physiotherapy protocols. Weight-bearing status was assessed at specific intervals and functional outcomes were evaluated using the American Orthopaedic Foot & Ankle Society score. Patients was divided randomly into 3 treatment groups: Group 1: Medial malleolus-ORIF with Medial malleolar screws Lateral malleolus-LCP, Group 2: Medial malleolus-ORIF with TBW. Lateral malleolus-K wire Group 3: Medial malleolus- ORIF with screws and k wire. Lateral malleolus-Recon plating.

The study utilized Excel and Graph pad Instat software for data entry and analysis, with descriptive-analytical and interferential statistical analysis using SPSS 21st version. Demographic details, fracture type, surgical technique, and functional scores were recorded, and functional outcomes were compared.

RESULTS

Total 102 adult patients divided into three treatment groups. The age distribution among participants was evaluated, with Group I comprising individuals aged 31-50 years and Group II and III having 61.7% and 58.8% respectively. The youngest cohort (18-30 years) was slightly more represented in Group III (29.4%), while the oldest age group (51-70 years) had the lowest representation. The gender distribution varied significantly among the three groups, with Group I having the highest proportion of male participants at 70.5% and Group III having the lowest at 55.9%. Female representation was highest in Group III at 44.1%, and lowest in Group I at 29.4%. In terms of fracture side distribution, Group III demonstrated the highest prevalence of right-sided fractures at 64.7%, followed closely by Group II with 61.7% and Group I with 55.9%. Left-sided fractures were most prevalent in Group I at 44.1%, decreasing through Group II at 38.2% to the lowest in Group III at 35.3%. The distribution of the mode of injury among the three treatment groups did not demonstrate statistically significant differences, as reflected by a p-value of 1.232. The most common cause of injury across all groups was slipping or stumbling, with Group III having the highest incidence at 53%. Road traffic accidents (RTAs) were also a notable cause, with Group I and II both reporting 35.3%, and Group III slightly lower at 29.4%. Sports-related injuries were the least frequent, ranging from 3% in Group III to 9% in Group II. Each mode of injury category showed similar distributions across the groups, indicating that the type of injury did not vary significantly between the different surgical intervention groups. (Table 1)

Table 1: Distribution of study groups as per the demographic profile, distribution of fracture side and mode of injury.

	GROUP I N=34 (%)	GROUP II N=34 (%)	GROUP III N=34 (%)	P-VALUE
GENDER				
MALE	24 (70.5%)	21 (61.7%)	19 (55.9%)	0.004*
FEMALE	10 (29.4%)	13 (38.2%)	15 (44.11%)	
AGE GROUPS (YEARS)				
18-30	9 (26.4%)	8 (23.5%)	10 (29.4%)	1.113
31- 50	19 (55.9%)	21 (61.7%)	20 (58.8%)	
51-70	6 (17.6%)	5 (14.7%)	4 (11.8%)	
MEAN ±SD	41.56 ± 11.9	43.82 ± 12.6	46.74 ± 13	
DISTRIBUTION OF FRACTURE SIDE				
RIGHT	19 (55.9%)	21(61.7%)	22 (64.7%)	0.001*
LEFT	15 (44.11%)	13 (38.2%)	12 (35.3%)	
Mode of Injury				
Slipping/ Stumbling	16 (47%)	15 (44.11%)	18 (53%)	1.2321.232
Fall from steps	4 (11.8%)	4 (11.8%)	5 (14.7%)	
Sports	2 (6%)	3 (9%)	1 (3%)	
RTA	12 (35.3%)	12 (35.3%)	10 (29.4%)	

The study also examined the time for clinical union following surgical treatments for bimalleolar ankle fractures. The majority of patients in Groups I and III achieved clinical union between 10-15 weeks, with 47.05% and 50% respectively. Group II had a notable peak at 5-10 weeks, with 47.05% achieving clinical union in this shorter time frame. The percentage of patients taking longer than 15 weeks to reach clinical union was highest in Group III at 26.4%, followed by Group II at 14.7%, and Group I at 9%. The mean time to clinical union varied significantly, with Group I averaging 7.57 weeks, Group II 8.11 weeks, and Group III notably longer at 13.46 weeks. In terms of radiological union, Group II had the highest percentage of patients achieving radiological union within 5-10 weeks at 47.05%, followed by Group I at 44.11%. However, Group III had a substantially lower rate in this early period, with only 23.5% reaching union. The study analyzed the time required for patients to achieve full weight-bearing status following surgical treatment for bimalleolar ankle fractures. It found significant differences among the three groups, with Group I showing a faster progression, while Group II had a slower progression. Group III showed a significant increase in progress, with 53% of its patients reaching full weight-bearing and 44.11% of Group III able to fully bear weight by 12 weeks. The mean times to full weight-bearing were 7.67 weeks for Group I, 8.33 weeks for Group II, and 12.31 weeks for Group III. The duration of hospital stay following surgical treatment for bimalleolar ankle fractures showed no statistically significant differences among the three groups. Most patients across all groups stayed between 5 to 10 days, with Group II recording the highest percentage at 64.7%. Short stays of less than 5 days were most common in Group III at 29.4%, while extended stays of more than 10 days were most frequent in Group I at 20.5%. (Table 2)

Table 2: Distribution of study groups as per the Time for clinical union (in weeks), Time for radiological union (in weeks), Time for weight bearing (weeks) and Duration of hospital stay

Time for Clinical Union (Weeks)	GROUP I (FREQ / %)	GROUP II (FREQ / %)	GROUP III (FREQ / %)	P-VALUE
5-10	1 (3%)	16 (47.05%)	8 (23.5%)	0.567
10-15	16 (47.05%)	13 (38.2%)	17 (50%)	
> 15	3 (9%)	5 (14.7%)	9 (26.4%)	
MEAN ± SD	7.57± 1.305	8.11 ± 1.299	13.46 ± 1.689	
Time for Radiological Union (Weeks)				
5-10	15 (44.11%)	16 (47.05%)	8 (23.5%)	
10-15	16 (47.05%)	13 (38.2%)	17 (50%)	0.044*
> 15	3 (9%)	5 (14.7%)	9 (26.4%)	
MEAN ± SD	11.80± 2.221	12.96 ± 2.262	14.71 ± 2.899	
Time for weight bearing (Weeks)				
5-10	24 (70.5%)	20 (58.8%)	1 (3%)	
10-15	6 (17.6%)	11 (32.3%)	18 (53%)	0.0021*
> 15	4 (11.8%)	3 (9%)	15 (44.11%)	
MEAN ± SD	7.67±1.402	8.33 ±1.667	12.31 ± 1.886	
DURATION OF HOSPITAL STAY (DAYS)				
< 5 days	8 (23.5%)	7 (20.6%)	10 (29.4%)	
5-10 days	19 (55.9%)	22 (64.7%)	21 (61.7%)	0.765
> 10 days	7 (20.5%)	5 (14.7%)	3 (9%)	
MEAN ± SD	8.44 ± 2.612	9.01 ± 3.17	9.67 ± 2.235	
TOTAL	34	34	34	

A study on surgical treatments for bimalleolar ankle fractures found no statistically significant differences in injury patterns among groups. The most common injury pattern was Supination-External Rotation, with Group III having the highest frequency at 61.7%. The most common injury pattern was Supination-Adduction, with Group I having the second most frequent pattern at 23.5%. Pronation-External Rotation injuries were more common in Group II at 23.5%. The least common pattern was Pronation-Abduction. The study also found significant differences in fracture types among the three groups. Type B fractures were the most prevalent, with Group II having the highest incidence at 64.7%. Type C fractures were most common in Group I at 29.4%. Type A fractures were least common and varied more significantly among the groups. Postoperative functional outcomes using the American Orthopaedic Foot and Ankle Society (AOFAS) score showed significant differences. Group I had the best outcomes, with 61.7% of participants achieving an 'Excellent' AOFAS score. The 'Good' category showed relatively closer percentages among the groups. The mean AOFAS scores further underscored these differences. (Table 3)

Table 3. Distribution of study groups as per the Injury Pattern, Danis-Weber Classification, and AOFAS Score

INJURY PATTERN	GROUP I N=34 (%)	GROUP II N=34 (%)	GROUP III N=34 (%)	P-VALUE

Supination-adduction	8 (23.5%)	5 (14.7%)	6 (17.6%)	0.345
Supination-External rotation	16 (47.05%)	18 (53%)	21 (61.7%)	
Pronation-Abduction	4 (11.7%)	3 (9%)	2 (5.8%)	
Pronation-External rotation	6 (17.6%)	8 (23.5%)	5 (14.7%)	
DANIS-WEBER CLASSIFICATION				
Type A	6 (17.6%)	3 (9%)	8 (23.5%)	0.005*
Type B	18 (53%)	22 (64.7%)	19 (55.9%)	
Type C	10 (29.4%)	9 (26.4%)	7 (20.5%)	
AOFAS SCORE				
Excellent	21 (61.7%)	18 (53%)	15 (44.11%)	
Good	10 (29.4%)	7 (20.5%)	8 (23.5%)	0.003*
Fair	3 (9%)	9 (26.4%)	11 (32.3%)	
MEAN ± SD	96.6 ±4.19	89.94 ± 7.29	85.67 ± 6.45	

The study investigated the functional outcomes of different combinations of screws, plating, and K-wiring in surgical treatment for bimalleolar ankle fracture in adults. The results showed significant differences in functional outcomes among different weight bearing groups, with 70.6% of the participants being weight bearing, and 55.9% being non-weight bearing. (Table 4)

Table 4: Distribution of study groups as per the WEIGHT BEARING:

Time for weight bearing (Weeks)	GROUP I N=34 (%)	GROUP II N=34 (%)	GROUP III N=34 (%)	P-VALUE
WEIGHT BEARING STATUS	24 (70.6%)	14 (41.2%)	4 (11.7%)	0.0001*
NON WEIGHT BEARING STATUS	3 (8.8%)	12 (35.3%)	19 (55.9%)	
PARTIAL WEIGHT BEARING	5 (14.7%)	7 (20.6%)	9 (26.5%)	
TOTAL WEIGHT BEARING	2 (5.9%)	3 (8.8%)	2 (5.9%)	
TOTAL	34	34	34	

DISCUSSION

Ancient Egyptian mummies show healed ankle fractures, while Hippocrates described lesions around the ankle joint as early as 300 BC. Initially, no treatment was needed for compound fracture dislocations, as patients were likely to die within 7 days. Sir Percival Pott, a surgeon at St. Bartholomew's Hospital in London, introduced the technique of repositioning the fracture in a flexed position to decrease severity. Ankle fractures make up about 9% of all adult fractures, and the prognosis depends on injury extent, anatomical realignment, cartilage and ligament damage, post-operative rehabilitation effectiveness, and concurrent medical disorders.[16]

This study is an interventional, prospective, randomized controlled trial involving 102 adult patients divided into three therapy groups. Group 1 patients undergo medial malleolus open reduction and internal fixation (ORIF) using screws and lateral malleolus locking compression plates (LCP), Group 2 patients undergo ORIF with tension band wiring (TBW) and lateral malleolus fixation with K-wiring, and Group 3 patients undergo ORIF using both screws and K-wiring on the medial malleolus, along with reconstruction plating on the lateral malleolus. Each group consists of 34 people, providing a substantial sample size for evaluating the results of these diverse surgical methods.

The study found that Group I (Screws) predominantly comprised adults between the ages of 31 and 50, accounting for 55.9% of its participants. The youngest age group (18-30 years) had a slightly higher representation in Group III (29.4%). The 51-70 years age group had the lowest number of participations, accounting for only 11.8% of the total participants. The average ages of Groups I, II, and III were 41.56, 43.82, and 46.74 years, respectively. The p-value of 1.113 indicates no statistically significant differences in age distribution among the groups, suggesting that the groups are similar in terms of age.[17,18]

The study analyzed the gender distribution of bimalleolar ankle fractures, focusing on three groups: screws, screws with K-wires, and screws with no K-wires. The male participants had the highest percentage of male participants at 70.5%, while the female representation was highest in Group III at 44.1%. The male to female ratio was 19:11, consistent with previous studies.[19, 20] The fracture side distribution among surgical treatment groups for bimalleolar ankle fractures revealed significant variance, with Group III having the highest occurrence of right-sided fractures at 64.7%, followed by Group II at 61.7%. In contrast, Group I had the lowest prevalence of right-sided fractures at 55.9%. Left-sided fractures were most common in Group I, accounting for 44.1% of cases. The prevalence of left-sided fractures decreased in Group II (TBW) to 38.2%, reaching its lowest point in Group III at 35.3%.

The study found no statistically significant changes in the distribution of the mechanism of damage across the three treatment groups. Slipping or stumbling was the primary cause of injury for all groups, with Group III having the greatest occurrence rate at 53%. Road traffic accidents (RTAs) were a significant contributing factor, with both Group I and II having a prevalence of 35.3%. The incidence of sports-related injuries varied from 3% in Group III to 9% in Group II, with the lowest frequency observed in sports-related injuries.

The distribution of injury types was similar across all surgical intervention groups, suggesting that the kind of damage did not significantly change between the groups. Ayyoub et al.[21] identified foot twisting as the primary cause of injury, followed by falls. Vala et al.[22] reported Road Traffic Accidents as the primary cause of injury, accounting for 17 patients (56.67%). This finding aligns with previous research by Rakesh Singh et al. [23] and Maruthi et. al. [24].

The study analyzed the length of hospital stay after surgical repair for bimalleolar ankle fractures, finding no significant changes in the distribution among the three treatment groups. The majority of patients in all groups had a hospital stay ranging from 5 to 10 days. Group II (TBW) had the greatest percentage at 64.7%, followed by Group III (Screws with K-wires) at 61.7%, and Group I (Screws) at 55.9%. In Group III, short stays of less than 5 days were the most prevalent, accounting for 29.4% of cases. On the other hand, in Group I, extended stays of more than 10 days were the most frequent, representing 20.5% of cases. The average duration of hospital stays was the least in Group I (screws) at 8.44 days and the longest in Group III at 9.67 days.

The study differed from other studies in terms of patient release procedures, as certain patients were discharged two or three days after the operation and were required to return to the outpatient department for stitch removal. Meanwhile, other patients were discharged only after their stitches had been removed.[25]

The study also found no significant variations in the time frames across the three groups. Approximately 47.05% of patients in Group I (screws) and 50% of patients in Group III (screws and K-wires) achieved clinical union within a timeframe of 10-15 weeks. Group II (TBW) had a significant surge at 5-10 weeks, with 47.05% of participants obtaining clinical union during this shorter time period. In contrast, just 3% of participants in Group I and 23.5% in Group III achieved clinical union.

The proportion of patients who took more than 15 weeks to achieve clinical union was highest in Group III, with a rate of 26.4%, followed by Group II with a rate of 14.7%, and Group I with a rate of 9%. The average time for clinical union differed significantly among the groups, with Group I having an average of 7.57 weeks, Group II with 8.11 weeks, and Group III notably longer at 13.46 weeks.

The study found significant variations across the groups in terms of the time required for radiographic union after surgical interventions for bimalleolar ankle fractures, as evidenced by a p-value of 0.044. Group II had the highest proportion of patients who achieved radiological union within 5-10 weeks, with a percentage of 47.05%. However, Group III had a significantly lower rate throughout this initial period, with only 23.5% achieving union.

The average durations for radiological union differed among the groups, with Group I having a mean period of 11.80 weeks, Group II with 12.96 weeks, and Group III being the longest with 14.71 weeks. This finding is comparable to previous studies, such as those conducted by Vala et al., Rakesh Singh et al., and Singhal et al.[22-26]

The study examining the duration of time it took for patients to reach full weight-bearing status after undergoing surgical treatment for bimalleolar ankle fractures found notable variations across the three groups. Group I exhibited a significantly accelerated rate of progression, with 70.5% of its patients attaining complete weight-bearing capacity within 6 weeks. By contrast, Group II achieved this milestone in 58.8% of cases during the same time frame, while Group III had significantly slower development, with only 3% achieving complete weight-bearing at 6 weeks. As the length extended to 8 weeks, Group III experienced a substantial rise, with 53% of its patients achieving full weight-bearing. By 12 weeks, 44.11% of Group III were able to fully bear weight, in contrast to 11.8% in Group I and 9% in Group II. The average durations for achieving full weight-bearing were 7.67 weeks for Group I, 8.33 weeks for Group II, and significantly longer at 12.31 weeks for Group III. The established protocol involved the removal of the cast after a duration of four weeks, followed by engaging in knee and ankle exercises. After six weeks, partial weight-bearing was permitted, and after 10 weeks, full weight-bearing was allowed for all three groups.[27,28]

The analysis of damage patterns, categorised according to the Lauge-Hansen classification, indicated that there were no significant variations. The Supination-External Rotation injury pattern was the most frequently observed, with Group III having the highest occurrence rate at 61.7%, followed by Group II at 53%, and Group I at 47.05%. In Group I, the Supination-Adduction pattern occurred most frequently, accounting for 23.5% of cases. The incidence of Pronation-External Rotation injuries was higher in Group II, with a prevalence of 23.5%, compared to 17.6% in Group I and 14.7% in Group III. The pattern with the lowest prevalence, namely 5.8%, was Pronation-Abduction, and it was observed least frequently in Group III.[22,23]

The study investigating the effectiveness of surgical treatments for bimalleolar ankle fractures found notable variations in the distribution of fracture types based on the Danis-Weber classification across the three groups. The most common type of fractures observed in all groups were Type B fractures. Among the groups, Group II had the greatest occurrence rate at 64.7%, followed by Group III at 55.9%, and Group I at 53%. The prevalence of Type C fractures, which are more intricate, was highest in Group I at 29.4%, followed by Group II at 26.4%, and Group III at 20.5%. In contrast, Type A fractures were the least frequent and had greater variation within the groups.[22]

Significant variations were identified in the examination of postoperative functional outcomes for bimalleolar ankle fractures among different surgical treatment groups, as shown by a p-value of 0.003, using the American Orthopaedic Foot and Ankle Society (AOFAS) score. Group I demonstrated the most favorable results, with 61.7% of its members attaining a 'Excellent' AOFAS score. In contrast, the proportion of patients classified as 'Fair' rose steadily from Group I to Group III, with Group III having the highest number at 32.3%. The mean AOFAS scores highlight the disparities across the groups, with Group I having the highest average score of 96.6, followed by Group II with an average score of 89.94, and Group III with the lowest average score of 85.67.[29,30]

The study emphasizes the importance of surgical modalities in bimalleolar ankle fractures, highlighting individual patient characteristics and the need for multi-center investigations and larger sample sizes. It also suggests the need for longer-term studies to evaluate fixation durability and identify late-onset complications.


PREOP X RAY


Post operative X-RAY of treated with malleolar screws and plating on lateral malleolus

Figure 1. Showing preoperative x-ray and postoperative x-ray of treated with malleolar screws and plating on lateral malleolus

CONCLUSION

The study reveals that surgical techniques for treating bimalleolar ankle fractures significantly impact clinical outcomes, radiological union times, and the time to achieve full weight-bearing. Group I, using medial malleolar screws and lateral locking compression plates, showed superior functional outcomes. The study also found that gender distribution and fracture side may influence the effectiveness of specific surgical treatments. The Danis-Weber classifications within each group also influenced the choice of intervention. The results emphasize the need for personalized surgical approaches based on individual patient demographics, fracture characteristics, and recovery timelines to optimize healing and functional recovery in bimalleolar ankle fractures.

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