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A retrospective study of functional outcome of surgically managed malleolar fracture at the ankle joint by subjective, objective and radiological assessment

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Abstract
Objective: To study the functional outcome of surgically managed malleolar fractures at ankle and to assess the results of complication.
Introduction: Ankle fracture is a common injury with potentially significant morbidity associated with it. Regardless of the method of the intervention, main goal is to restore normal anatomy. Complications associated with both conservative and operative management are an important consideration in decision making. Patient selection is very important in deciding the type of management. This paper provides an update to surgical management of ankle fractures.
Methodology: Medical records of 96 patients were studied and data was collected which includes the demographic data, fracture details, intraoperative and postoperative details. Then patients were called up for follow-up. The functional outcome of these patients was assessed subjectively using OLERUD MOLANDER ANKLE SCORE (OMA) score. Objective and radiological outcome was assessed using cedell's criteria.
Results: Among the 96 patients we achieved excellent and good subjective results in 60 (62.5%) patients; Good objective result in 72 (75%) patients; Good radiographic results in 80 (83.4%) patients. In our study, patients with unimalleolar fractures had the best outcome. Trimalleolar fractures had the worst outcome. Bimalleolar fracture had intermediate outcome. With regards to lateral malleolar fracture fixation modality, patients with rush nail achieved good to fair radiological and objective outcome with no poor outcomes With regards to medial malleolar fracture fixation modality, patients with Tension band achieved good objective and radiological outcome and there were no poor outcomes. In patients with malleolar screw fixation 62.5 % patients achieved good objective and 75 % patients achieved good radiological outcome. Patients with complications has poorer outcome. In patients with superficial infection the outcome was poorer.

Keywords: Ankle fractures, olerud molander ankle score, cedell score

1. Introduction
Ankle fractures are one of the most common lower limb fractures [1] they account for 9% of all fractures [2] representing a significant portion of the trauma workload [3]. The annual incidence of ankle fracture is between 107 and 187 per 100,000 persons [4-6], and around 2% of ankle fractures are open fractures [4]. Ankle fractures usually affect young men and older women, however, below the age of 50 ankle fractures are the commonest in men. After this age, females become predominant. Alcohol and slippery surfaces are each involved in nearly a third of the cases [6]. Twisting injuries and falls, followed by sports injuries [4] are the most common causes of ankle injuries. Diabetes and obesity are associated with fractures in middle aged and older adults [5]. Most fractures are associated with ligament injuries, and the magnitude and direction of the deforming force applied to the ankle joints directly correlate to the fracture.
As has been shown experimentally by Paul L. Ramsey, about 1 mm lateral shift in talus produces about 42 percent of decrease in tibio-talar contact area [7]. Hence perfect anatomical reduction is required, which could be better, achieved by open reduction and better maintained by internal fixation.

2. Materials & Methods

2.1 Study Design: Retrospective Study

2.2 Source of Data

The data for this study was collected from 96 patients fulfilling the inclusion/exclusion criteria admitted as IP in Kadimi hospital during the period from January 2009 to August 2015

2.3. Sample size justification

The incidence of ankle fractures in Peter J. Daly *et al.* [8] study was 187 per 100,000/ year. So, anticipated/ hypothesized frequency of ankle fractures is taken as 18.7 % with confidence level of 90%, sample size comes as 116 according to OPEN EPI formula. As the present study is complete enumeration of patients admitted during the period from January 2009 to August 2015, the sample size of the present study comes to 96.

2.4 Inclusion Criteria

a) Displaced malleolar fractures at the ankle in adults were included
b) Complete case record available for review, including x-rays, as well as regular follow up at our hospital.
c) Patients aged 20 years and above

2.5 Exclusion criteria

a) Undisplaced fractures and the fractures treated conservatively.
b) Patients aged below 20 years, in whom epiphyseal closure has not occurred.
c) Delayed ankle fractures with malunion or nonunion
d) Pilon fractures and only ligamentous injuries

2.6 Method of collection of Data

- Retrospective study was undertaken. Study period was from January 2009 to August 2015
- During this period the patients who were admitted in Kadimi Hospital, Hyderabad, for surgical management of ankle fracture were studied.
- 102 patients were admitted during this period. Among them, 2 patients were lost from follow up due to various reasons and 4 patients were not fulfilling the inclusion/exclusion criteria. The remaining 96 patients were included in the study
- Records of the 96 patients studied. Important data including patient details, mode of injury, date of injury, anatomy of fracture, and date of surgery were obtained from the records. Operative details taken from the records to determine the surgical technique.
- The number patients of which the data is obtained and their respective years are depicted in the below table.

Year	No. of patients
2009	18
2010	14
2011	16
2012	18
2013	18
2014	12
Total	96

- Patients were then called up for follow-up in the months of January and February 2015
- The follow up period ranged from 6 months to 54 months
- Patients were told in detail regarding the study and informed consent was taken
- X-ray of ankle AP & Lateral were taken and analyzed during this visit of the patient

For functional evaluation of patients we have chosen the following Scoring systems.
Cedell scoring system
Olerud and Moleander scoring system
Modified Cedell scoring system

2.7 Criteria for evaluation of functional outcome

Subjective outcome criteria.

Olerud and molander ankle scoring system (OMAS) [9]

S. No.	Parameter	Degree	Score
1	Pain	None	25
		While walking on even surfaces	20
		While walking on even surface outdoors	10
		While walking indoors constant and severe	5
2	Stiffness	None	10
		Stiffness	0
3	Swelling	None	10
		Only in the evenings	5
		Constant	0
4	Stair climbing	No problems	10
		Impaired	5
		Impossible	0
5	Running	Possible	5
		Impossible	0
6	Jumping	Possible	**5**
		Impossible	**0**
7	Squatting	No problems	5
		Impossible	0
8	Supports	None	10
		Wrapping, taping	5
		Stick, crutches	0
9	Work, activities of daily life	Same as before	20
		Loss of tempo	15
		Change of simpler job	15
		Severely impaired work capacity	0

Olerud molander ankle score (OMAS)

The Olerud Molander Ankle Score (OMAS) is a self-administered patient questionnaire developed to evaluate symptoms following surgery of ankle fractures[9]. Score is rated from 0 (totally impaired) to 100 (completely unimpaired) consisting of 9 questions. The first 3 questions include primary complaints (pain, stiffness and swelling), next 4 questions cover ability to perform simple tasks (stair-climbing, running and jumping) and the last two questions concern the patient's situation in everyday life.
The subjective score was classified into four groups;
Poor (<60),
Fair (60-80),
Good (81-90) and
Excellent (>90)

2.8 Objective Outcome Criteria

Cedell Scoring System [10]

S.no	Criterion	Good	Fair	Poor
1	Gait	Normal	Occasional limp	Frequent limp
2	Intermalleolar distance	0-1 cm	1-2 cm	>2 cm
3	Calf atrophy	0-1 cm	1-2 cm	>2cm
4	Ligamentous tenderness	None	Mild	Severe
5	Loss of motion of ankle	$0\text{-}10^0$	$10\text{-}20^0$	20^0
6	Pes planus	None	Mild	Severe
7	Heel valgus	None	Mild	Severe
8	Swelling	Minimum	Mild	Sever
	Scores	3 points	2 points	1 point

These parameters are graded as mild moderate and severe for which 1, 2, 3 points are given respectively.
A good rating has total score of >23,
Fair score is between 21 and 22.
Poor score is less than 20

2.9 Criteria for Radiological Outcome

Criteria by Cedell, Leeds & Ehrlich *et al.* [11]

S. No		Criteria, Rating, Score		
1	Lateral malleolus	No Lateral displacement Anterior, posterior or proximal Displacement <2mm	Mild	3
		Lateral displacement <2mm Anterior, posterior or proximal displacement 2 to 4mm.	Mod	2
		Lateral displacement>=2mm Anterior posterior or proximal Displacement > 4mm	Severe	1
2	Posterior Malleolus	Proximal displacement <2mm	Mild	3
		Proximal displacement 2 to 5mm	Mod	2
		Proximal displacement > 5 mm	Severe	1
3	Medial joint space	No widening	Mild	3
		Widening <=1mm	Mod	2
		Widening >1mm	Severe	1
4	Syndesmosis	<=5mm wide	Mild	3
		5 to<7 mm wide	Mod	2
		>=7mm wide	Severe	1

This criterion includes 4 parameters viz., posterior malleolus, lateral malleolus, medial joint space and syndesmosis. These parameters are graded as mild moderate and severe for which 1, 2, 3 points are given respectively.
A good rating has total score of >11,
Fair score is between 8 and 10
Poor score is less than 7

3. Results

Epidemiology: The age of the studied patients were in the range of 20 – 65 yrs. Most of the patients were in the age group of 50 – 65 yrs with 60 patients (62.5%) being between 40-65 years and 36 patients (27.5%) being between 20 – 39 years old. 56 patients (8.3 %) were male whereas 40 patients (41.7 %)were females. Left side was involved in 54.2% of patients as compared to the injury to the right side in 45.8% patients.

Mechanism of injury: The most common mode of injury was found to be road traffic accidents (50 %) followed by slip and fall (41.7%) and others contribute to 8.3%.

Associated Medical Problems: The total number of patients with the other co-morbid conditions was 60. Out of which 24 patients were diabetic, 16 patients with hypertension, bronchial asthma in 4 patients, and two each having hypothyroidism, coronary artery disease and CVD.

Type of Injury: Closed injures were observed in 72 patients (75%) whereas 24 patients (25%) had compound fractures or fracture dislocations. Among them 4 (4.2%) were technically compound, 8 (8.3%) were Grade 1 Gustilo Anderson, 8 (8.3%) were Grade II and 4 (4.2%) were Grade III A.

Distribution of patients according to Fracture classification

a) Webers classification

Type of Fracture	No. of patients	Percentage
Type A	22	23%
Type B	26	27%
Type C	48	50%

b) Lauge Hansen classification

Type of fracture	No. of Patients	Percentage
Supination External rotation	26	27.2%
Supination Adduction	10	10.4%
Pronation External rotation	19	19.7%
Pronation Abduction	41	42.7%

c) Henderson Classification

Type of Fracture	No. of patients	Percentage
Trimalleolar fractures	18	18.79%
Bimalleolar fractures	57	59.39%
Isolated malleolar fractures	21	21.8%

Type of Fixation in particular fractures

("n" Indicates the number of patients with particular condition)

Part	Type of Fixation	No. of Patients	Percentage
Medial malleolus (n=96)	Malleolar /cancellous screws	64	66.7%
	Tension Band technique	32	33.3%
Later malleolus / Distal Fibula (n=76)	One third Tubular plate	60	79%
	Rush nail	16	21%
Posterior malleolus (n=20)	Lag screw(s)	12	60%
	No fixation	8	40%
Syndesmotic injury (n=8)	Syndesmotic screw Through fibular plate	8	100%

Complications

	No. of Patients	Percentage
No complications	79	78.2%
Non union of medial malleolus	6	
Non union of fibula	3	
periarticular osteoporosis	5	
Superficial wound infection	7	
Total patients with complications	21	
		21.8%
Total	96	100%

Overall functional outcome

Functional outcome	All patients		
Subjective by OMAS mean value	Excellent	20	20.8%
	Good	40	41.6%
	Fair	32	33.3%
	Poor	4	4.2%
Objective	Good	72	75%
	Fair	20	20.8%
	Poor	4	4.2%
Radiological	Good	40	83.3%
	Fair	6	12.5%
	Poor	2	4.2%

Functional outcome of unimalleolar fractures

Functional outcome	Value	
Subjective by OMAS mean value	**94**	
Objective	Good	100%
	Fair	0
	Poor	0
Radiological	Good	100
	Fair	0
	Poor	0

Functional outcome of bimalleolar fracture

Functional outcome	Value	
Subjective by OMAS mean value	**90**	
Objective	Good	78%
	Fair	22%
	Poor	0%
Radiological	Good	92%
	Fair	8%
	Poor	0%

Functional outcome of trimalleolar fracture

Functional outcome	Value	
Subjective by OMAS mean value	**78.88**	
Objective	Good	40%
	Fair	40%
	Poor	20%
Radiological	Good	40%
	Fair	40%
	Poor	20%

Functional outcome in lateral malleolus fractures fixation
Rush Nailing

Functional outcome	Value	
Subjective by OMAS mean value	**86**	
Objective	Good	50%
	Fair	50%
	Poor	0%
Radiological	Good	50%
	Fair	50%
	Poor	0%
Mean full weight bearing	8.6 weeks	

Indications for using rush nailing: Rush nail was used in fractures where the over ridding of fractures is not expected like in transverse short oblique fibula fractures which are seen is Supination Adduction, Supination External Rotation, Pronation Abduction injuries.

One third Tubular plate

Functional outcome	Value	
Subjective by OMAS mean value	**87**	
Objective	Good	73%
	Fair	20%
	Poor	7%
Radiological	Good	86%
	Fair	7%
	Poor	7%
Mean full weight bearing	10.3 weeks	

Functional outcome in patients with medial malleolus fracture fixation
Malleolar screw fixation

Functional outcome	Value	
Subjective by OMAS mean value	**86**	
Objective	Good	62.5%
	Fair	31%
	Poor	7%
Radiological	Good	75%
	Fair	18%
	Poor	7%
Mean full weight bearing	10.2 weeks	

Tension band wiring

Functional outcome	Value	
Subjective by OMAS mean value	**93**	
Objective	Good	100%
	Fair	0%
	Poor	0%
Radiological	Good	100%
	Fair	0%
	Poor	0%
Mean full weight bearing	9 weeks	

Functional outcome in posterior malleolus fracture fixation

	Results	No of patients	Percentage
Subjective	Excellent	Nil	-
	Good	8	67%
	Fair	Nil	-
	Poor	4	33%
Objective	Good	8	67%
	Fair	-	-
	Poor	4	33%

Radiological	Good	8	67%
	Fair	-	-
	Poor	4	33%

Functional outcome among fractures with syndesmotic screw injuries

Functional outcome	Value	
Subjective by OMAS mean value	**70**	
Objective	Good	50%
	Fair	0%
	Poor	50%
Radiological	Good	50%
	Fair	0%
	Poor	50%

4. Discussion

96 patients were followed and results analyzed for internal fixation in displaced ankle fractures by using the AO-ASIF principles.

The mean age of patients obtaining an ankle fracture is 44 years. Below the age of 50, ankle fractures were commonest in men [69%]. After this age, females became predominant.

Left side more commonly affected [54%] compared to the right side. Most common mode of injury was Road traffic accident. Most common mechanism of injury was pronation abduction [45%] followed by supination external rotation mechanisms [25%].

Less favorable results were obtained in trimalleolar fractures (mean OMAS 78.88) whereas most favorable results were obtained among unimalleolar fractures (mean OMAS 94). In addition to this the result is influenced by the size of the posterior malleolus.

Fixation modality

Fibula fixation

In our study, fibula was fixed with either by 1/3rd Tubular plate or by Rush nails. Rush nail was mostly used in transverse fractures, short oblique fibula fractures where overriding is not expected. It was not used in the spiral fractures which is seen in PER injuries which if used will results in overriding of the fragments and would disturb the congruity of the joint.

The present study found that all the patients managed with rush nails had a good or fair functional result. In addition, patients with Rush nail treatment were able to resume full weight bearing by 8.6 weeks whereas patients fixed with screws and plates resumed weight bearing by 10.3 weeks which was one and half week later compared to patients fixed with rush nails. This was similar to the study conducted by Pritchett JW *et al.* [12] whose patient's experienced early resumption of weight bearing compared to plate fixation.

Rush pin in distal third fibular fracture is a safe and effective method of surgery that could be performed easily as well as minimal soft tissue disruption and did not require secondary surgery to remove the wire, and showed sufficient stability after fixation [13], while it may not control the rotation of fragment neither can effectively maintain the length of the fibula as compared with the plate fixation but such situation can be kept to minimum with good surgical and postoperative management [13]. Hence rush nailing can be encouraged as a good modality of treatment wherever possible for fibula fixation.

Medial malleolus fixation

In our study medial malleolus was fixed with either by Tension band wiring or by Malleolar screw. The current study showed that mean OMAS of 86 was achieved in patients treated Malleolar screw fixation and a mean OMAS of 93 was achieved in patients with Tension band wiring. This agrees with the results of Mohammed *et al.* [14] who achieved excellent and good results in 80% patients with malleolar screw fixation and 90 % in patients with tension band wiring.

In our study the mean time for full weight bearing for patients with tension band wiring was 9 weeks where as with malleolar screw fixation was 10.2 weeks.

Mohammed *et al.* [14] in their study have opined that the tension-band wiring is more technically advantageous for small fragment fixation of medial malleolar fractures and may be more available and its usage could translate into overall cost saving when applied to the large number of ankle fractures treated surgically in our country. We agree with their study however it is not recommended for the fixation of vertical fracture medial malleolus [15].

In our study of 96 fractures treated, 10% of patients had syndesmotic screw fixation. All belonged to type C Weber injury. At follow-up the mean Olreud and Molander score was 70. This was similar to the study conducted by Weening *et al.* [16] who had 12% of patients treated with syndesmotic screw fixation the mean Olreud and Molander score during follow up was 74.1%.

In all the patients, we removed the syndesmotic screw 10-12 weeks after the surgery and allowed weight bearing.

According to Hak *et al.* [17] a posterior malleolus fracture is present in 14% to 44% of patients with an ankle fracture. Findings of our present study correlate with their observation. In our study 20.8 % patients had posterior malleolus fracture.

In a study by Broos [18] *et al* have found that if there was a posterior fragment present, only 66% of the patients had an excellent or good result compared with 81% of the patients without a posterior fragment. In our study 60 % of patients had excellent or good results if there was a posterior fragment present where as it was 84% without a posterior fragment.

They also noted that increasing posterior malleolar fragment size was associated with poorer functional outcomes than a large posterior fragment. We agree with their study as we found that poor results in functional outcome (33%) was obtained in patients with larger posterior fragment in spite of surgical fixation, where as there were no patients with poor outcome in patients with small unfixed posterior fragment.

Postoperative immobilization

Early mobilization has been associated with an increased risk for wound complications. Based on the current literature, a patient with higher risk for postoperative infection should probably be treated with a cast following ankle fracture surgery [19].

In obese and diabetic patients a longer period of non- or partial weight bearing is recommended, as premature weight bearing is the greatest contributing factor to a loss of

reduction in this patient population [20].

A significantly lower number of infections were observed when a cast was applied in the operating room following ankle fracture operations. Furthermore, cast application in the operating room probably protects the surgical wound from bacterial contamination, since the dressings are less likely to be opened during the following few days [21]. Hence, we preferred postoperative immobilization rather than allowing active ankle exercise.

In our study we immobilized every patient with below knee pop slab. The average period of immobilization was 3.75 weeks (range 0-6 weeks). We achieved 30 degrees or more plantar flexion in 36 patients (75%) and 20 degrees or more dorsiflexion in 40 (83%) patients.

Complications

The overall complication rate following ORIF of ankle fractures varies considerably in the literature ranging from 1% to 40% [22]. In our study it was 21.8 percent. SSI is the most common complication following ankle fracture surgery. The incidence of SSI following operative treatment of ankle fractures varies considerably in the literature, ranging from 1.4% to 5.5% [22]. In our study it was 7.29 %.

Korim *et al.* [23] in 2014, studied patient- and surgery-related risk factors for surgical site infection following open reduction and internal fixation of an ankle fracture. They found that surgical site infections result in lower functional scores as assessed by using the Olreud and Molander Ankle Score.

In our study the mean Olreud and Molander Ankle Score among patients with surgical site infections was low i.e., 69. Poor results were obtained in among 48% patients. Time taken for full weight bearing was also longest i.e., 12.3 weeks among these patients.

Patients at higher risk for postoperative complications

A large population-based study conducted by Soohoo *et al*. 2009 [22] noted that open injuries, diabetes, old age, Weber C were strong risk factors predicting a complicated short-term postoperative course [24-25]. we agree with Soohoo *et al* as 40 % of patients who encountered with complications were diabetic and 40 % patients who encountered with complications had open injury.

Diabetes

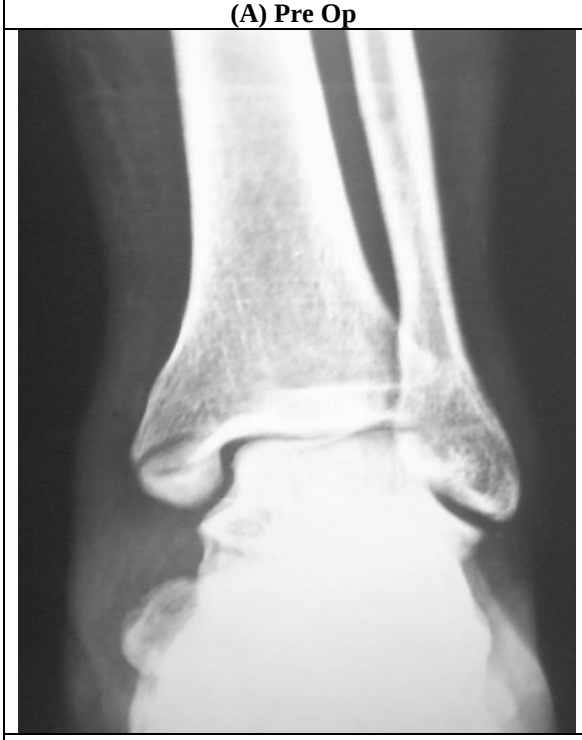
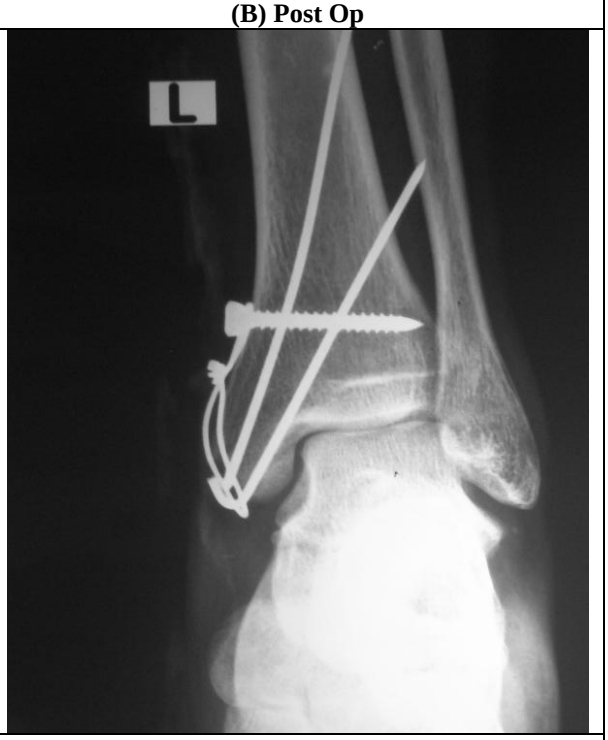
Patients with diabetes have higher complication rates for both open and closed management of ankle fractures. Infection rates as high as 19% have been reported in diabetic patients (Jones *et al*. 2005) [26]. A study of 57,183 surgically treated ankle fracture patients conducted by Soohoo *et al*. in 2009 [22] reported that diabetes is a strong predictor of short-term complications. In our study 40 % of patients who encountered with complications were diabetic leading to financial burden due to longer hospital stay.

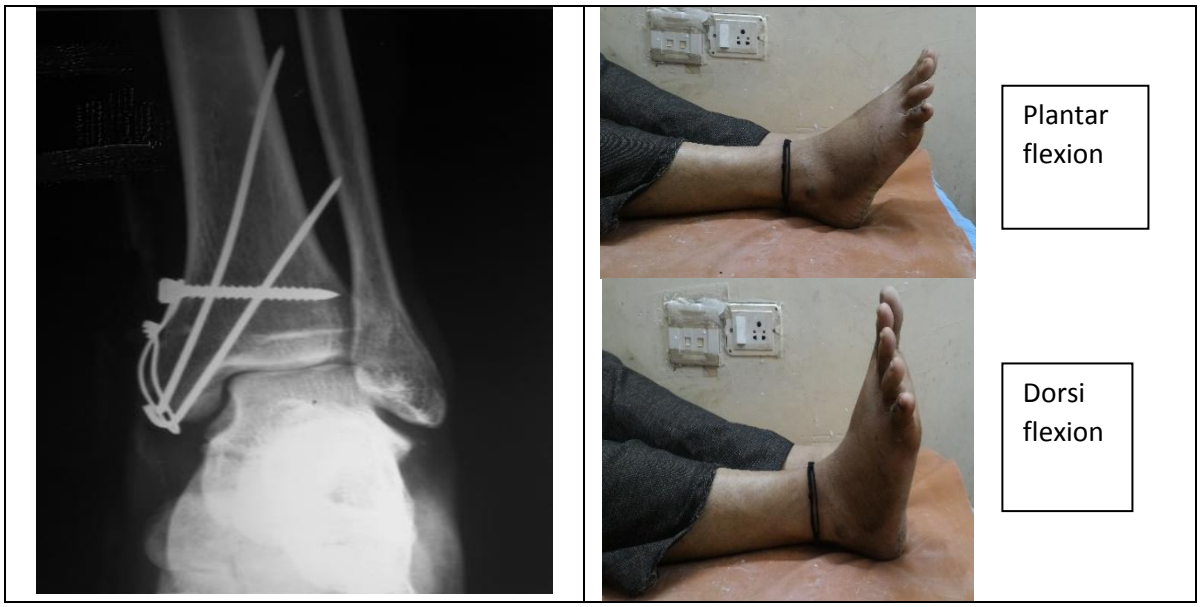
Open injuries

Johnsen & Lance [27] did a study on open reduction and internal fixation in the field of open ankle fractures. They achieved 64% excellent, 23% good and 13% poor results. In our study group among the 12 compound fractures, excellent results were achieved in 2 (16.7%), good results in 6 (50%), fair results in 2 (16.7) and poor results in 2 (16.7%) patient in term of subjective outcome.

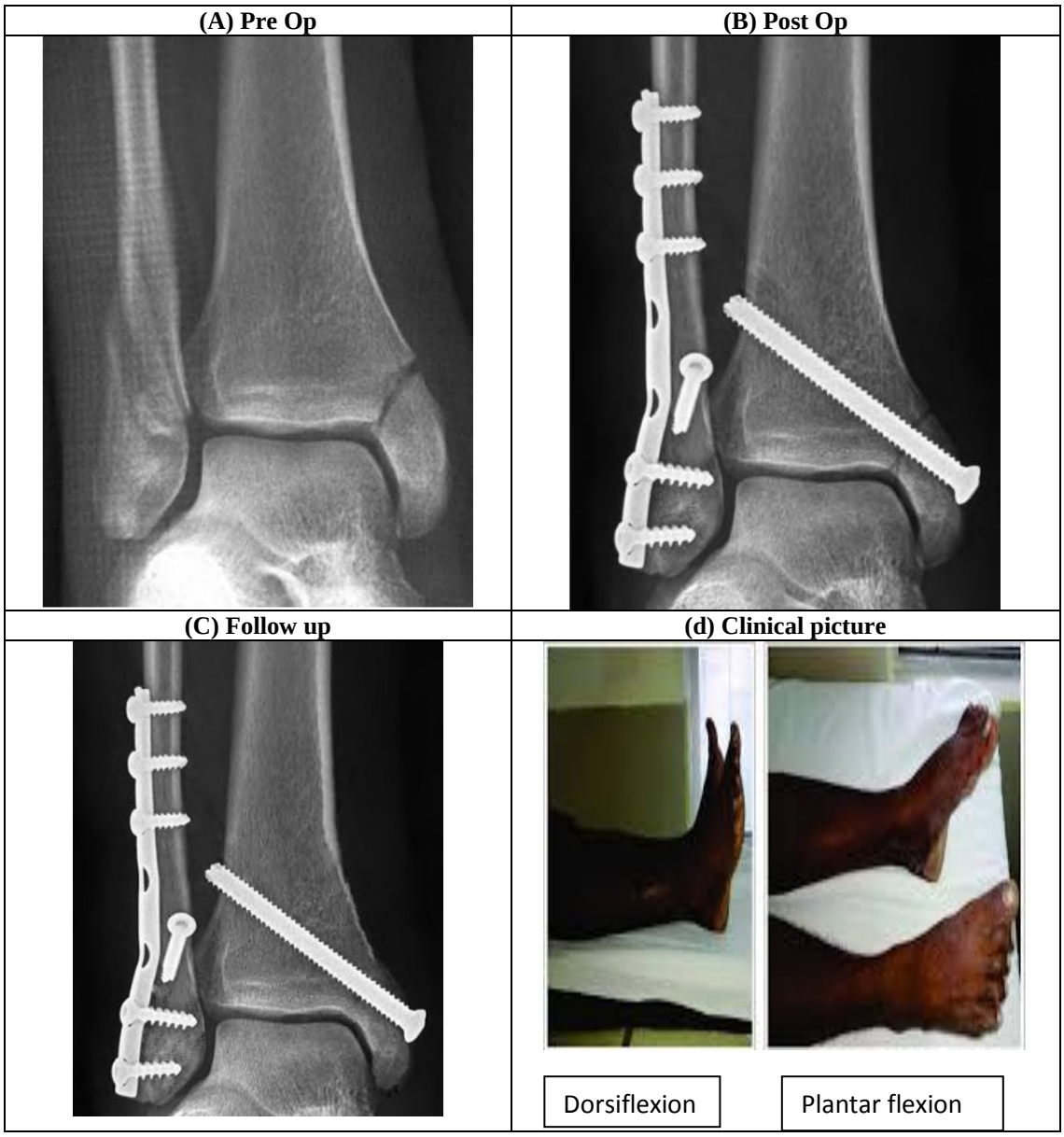
The case which yielded poor results was Grade II injury associated with severe comminution of fibula above the syndesmosis. It was treated initially with thorough wound wash and pop slab 2 wks, followed by ORIF. In this case we noted fibular nonunion which was asymptomatic, The poor results in grade II & III compound fractures may be attributed to non-anatomic reduction, articular surface damage and delay in fixation of fractures.

Case 1

(A) Pre Op	(B) Post Op
	
(C)Follow up	**(d)Clinical picture**



Case 2



Limitations

The study group was relatively small, with a shorter duration of follow up. Variations in surgical techniques and experience, fracture patterns, errors of measurement and patient adherence to postoperative mobilization regimens could not be accounted for in this study.

5. Conclusion

1. Most of the ankle fractures were due to indirect violence, occurred more frequently in adult population.
2. Pronation abduction injury were more common in our study in contrast to other studies
3. It has been found that most of the fibular fractures were supra syndesmotic with Partial or total rupture of syndesmotic ligaments.
4. Proper preoperative planning, good operative skills and excellent postoperative Management were needed to obtain the best results.
5. Early and extensive wound debridement with copious irrigation and stable internal fixation that is minimally disruptive to vascularity and function of ankle will give good Results in Grade I, II& IIIA open ankle fractures.
6. The post operative cast immobilization will not cause restriction of range of Motion ankle and it aids in better healing of soft tissues around the ankle.
7. The functional outcome following a trimalleolar fracture appears to be less favorable than unimalleolar and bimalleolar fracture
8. Rush nailing appears to have better functional outcome compared to one third tubular plate for the lateral malleolar fracture fixations
9. Tension band wiring appears to have better functional outcome compared to malleolar screw fixations
10. Patients with Open injuries, diabetes, old age, Weber C type, and infectious wound gave poorer functional outcomes.

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