Research Article

Management Of Tibial Pilon Fractures With Spanning External Fixator Supported By K-Wires Fixation

Zaid W. Al-Shahwanii, *F.I.C.M.S (othro)*
Assistant Professor, *Head of fractuers & orthopedic surgery department ,Al mustansriya medical college*
Consultant orthopedic surgeon

Date Submitted: 3/11/2016
Date Accepted:29/3/2017

Address for Correspondence:
Assistant Professor
Dr. Zaid W. Al-Shahwanii
Head of fractuers & orthopedic surgery department
Al mustansriya medical college
Consultant orthopedic surgeon
F.I.C.M.S (othro)

Abstract

Background: Pilon fractures of distal tibia result from axial load with high energy force That produce a spectrum of articular and metaphseal fractuers which are difficult to manage , especially when associated with soft tissue injuries with a high rate of complications when treated with primary open reduction & internal fixation, this drive the surgeon's to use spanning external fixator & limited internal fixation like k-wirs as an alternative techique for definitive management.

Patients & Method: Twenty cases of fractures of tibial pilon were collected; studied & treated in Al-Yarmook teaching hospital and Red Crescent surgical hospital during the period from October 2013 - october 2015..

The average age of the patients were thirty five years (range from twenty to fifty years),16 cases were male, 4 cases were female.. 14 cases of them had associated fibular fracture .

all are managed by Spanning External fixation with k-wires supplment as an internal fixation to hold the scattered pieces of articular surface ..

Results: among those 20 cases there are 8 cases had a good results regarding ankle movement a good union with preservation of ankle mortise .While 9 cases had fair results due to either mal-union or limitation of ankle movements and only 3 cases

ended with poor results. There were only two cases complicated with infection (tibial osteomyelitis) (caseNo. 10 & No. 13) & were treated by proper antibiotics according to culture & sensitivity, also we had nine patients complain from pin tract infection which were treated by antibiotics and daily dressing.

Discussion: The use of external fixation supported by k-wires to treat the metaphyseal portion of pilon (tibial plafond) fractures with articular surface involvement has been reported to be associated with a lower rate of wound complications than open reduction & internal fixation.. and a good result of union .

Key words: Pilon fracture , External fixation , K-wires

INTRODUCTION

Definition of pilon fractures:

The tibial Pilon fractures (which often present a challenge in practice for orthopeadic surgeons); comprises anatomically of a fractures distal end of tibia including the articular surface. it is high energy axial loading trauma leading to the articular damage in the weight bearing area with extensive injury of the surrounding soft tissue, and a high complications rate.. It's proximal limit is found (8-10cm) from ankle tibial fractures represent about **(10-15 %)** from all the body fractures and tibial pilon fractures about **(5-7%)** of all tibial fractures.[1,2]

The choice of treatment must consider reduction & fixation of the fractures, and the management of the soft tissue injury which is a frequent cause of subsequent complications , with preservation of the ankle mortise and avoiding the development of late secondary osteoarthritis of the ankle joint.[3]

Clinical Types: Based on mechanism of injury & damage of soft tissues & bone , pilon fracture can be divided into two main categories low impact Pilon fractures or more often type High impact Pilon fractures usually high energy axial compression associated with extensive soft tissue injury , sever articular comminution as in motor vehicle accident or blast injury lead to upward impaction of the tibial plafond compressing the metaphyseal cancellous bone.. Axial loading has also shown to cause cartilage necrosis & may be responsible for poor outcomes despite anatomical radiographic reconstruction.[4]

Fractures Classification System: The two main classification system used for fractures of tibia plafond are the Rüedi-Allgower (1969) & (AO / OTA) systems , both of them are descriptive system. The Rüedi is moderately useful ,it divide the fractures into three types based on the displacement & degree of comminution of the articular surface: [5,6]

Type I: intra articular fractures without displacement.

Type II: displacement without comminution.

Type III: displacement & comminution of the articular fragment

Radiological Evaluation: X-rays (AP, Lat., mortise view). CT-scan : are extremely useful for determining accurately the direction of fractures line; the size & displacement of articular fragment ; extent of comminution & impaction ,,, help in planning of surgical incision & fractures approach ,,usually CT-scan & plain radiographs obtained using skeletal traction in order to decide preoperative planning , using calcaneal traction pin and Bohler frame.[7]

PATIENTS AND METHODS

Twenty cases of fractures tibial plafond were collected; studied &treated in Al-Yarmook teaching hospital & Red crescent surgical hospital during the period from October 2013 to October 2015. The average age of the patients was 35years (range from 20-50 y.). Sixteen patients were male & four patients were female.
The most common cause of injury were motor vehicle accidents (8cases); fall from hight (7 cases) & blast injury (5 cases) as in fig (1) & there was high prevalence of associated skeletal injury(3 cases)had (femoral shaft fra ctures in ipsilateral side) & also there was (7cases) ass ociated with other systemic injury in head , chest , abdomen. While we have ten cases with isolated pilon fractuers.

We have 14 cases with fibular fractures & 6 cases with intact fibula(fig.2) There were only two cases complicated with infection (tibial osteomyelitis) (case No. 10 & No. 13) & were treated by proper antibiotics according to culture & sensitivity, also we had nine patients complain from pin site infection which were treated by antibiotics and daily dressing .

No case of fractures talus .

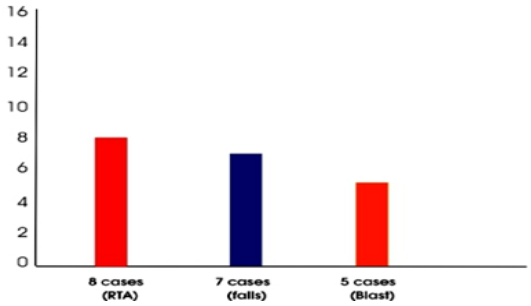

Figure 1: causes of fractures

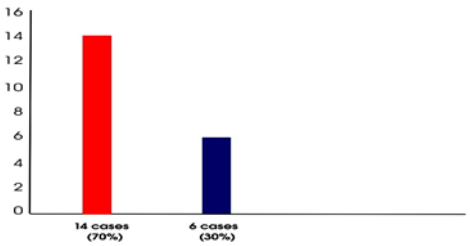

Figure 2: fractuer fibula

There were (3) cases presented with partial comminuted articular fracture as part of the joint surface remain intact, while in the other (17) cases have total articular surface fracture, (5) cases of those (17) cases had a mild fragmented metaphyseal fractures & (12) cases had sever comminuted metaphyseal fractures with intact fibula .

Seven cases of our data were associated with open wounds, according to Gustilo classification :-
two cases had type I; two cases had type II & three cases had type (III A)the remaining patient (13cases) were close injury & ten cases of them had fracture blister with bad skin cover & soft tissue as seen in table (1) (all these patient had a CT-scann preperativly).

Table 1: Data of Twenty Patients

No. of Case	Age & Sex	fracture classification	Wound classification according to Gustilo	Fibular fractures	Duration of fixation	Dorsiflexion & planterflexion of ankle N.V(0-15/0-40)	Subtalar movement inversion / Eversion (n.v 0-30 / n.v 0-15)	Results of reduction
1	M; 35 Year	C3	Type I	Yes	6 months	10/30	15/10	Fair
2	M; 30 Year	C1	Close	Yes	4 months	10/35	10/7	Good
3	M; 45 Year	C3	Type II	Yes	4 months	10/35	15/8	Fair
4	M; 39 Year	C1	Close	Yes	4 months	10/25	20/10	Good
5	M; 36 Year	B2	Close	Yes	6 months	5/30	25/10	Poor
6	F; 36 Year	C2	Close	Yes	5 months	15/25	20/10	Fair
7	M; 50 Year	C1	Close	No	3 months	10/30	25/10	Good
8	M; 25 Year	C3	Type III A	Yes	4 months	10/30	20/10	Good
9	M; 30 Year	C3	Close	Yes	4 months	10/25	15/10	Good
10	M; 41 Year	C3	Type II	Yes	7 months	10/15	5/5	Fair
11	M; 25 Year	C1	Close	No	6 months	10/25	15/10	Good
12	M; 40 Year	C3	Close	Yes	5 months	10/20	10/5	Poor
13	M; 40 Year	C2	Close	No	6 months	8/20	20/10	fair

14	F; 40 Year	C2	Type I	Yes	5 months	10/25	25/5	Fair
15	M; 35 Year	C3	Close	Yes	6 months	10/20	10/5	Fair
16	M; 30 Year	C3	Type III A	Yes	5 months	15/15	10/5	Fair
17	F; 25 Year	B3	Close	No	4 months	5/15	20/10	Fair
18	M; 20 Year	C1	Close	No	5 months	10/20	25/10	Good
19	F; 30 Year	C3	Type III A	Yes	4 months	8/20	10/5	Poor
20	M; 30 Year	B2	Close	No	5 months	10/20	10/5	Fair

Operative technique & post-operative management:

The fixator was applied in the operating room on radiolucent operating table with use of fluoroscopic control...Scrapping and draping to the lower limb from the toes up to the knee joint done. Pins were inserted in the hind foot in the posterior Os of the calcanium and neck of talus, (this is a standard AO technique) so they will straddled the neurovascular bundle and the subtalar joint.

The pins were placed parallel to the dome of the talus & this minimized talar tilt when fixator was applied; the orientation of the hinge was determined by these pins plus proximal two or three tibial pins placed in the antro-medial border of tibial shaft

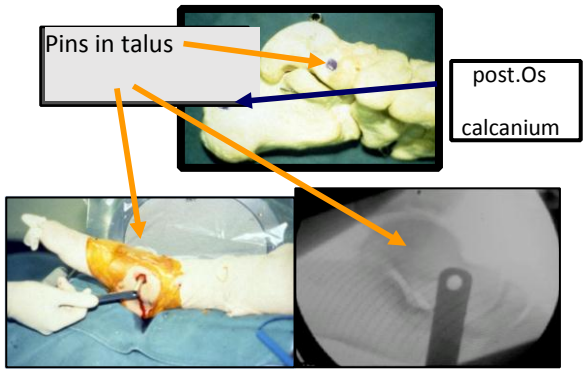

Figure 4: pins positions

After placement of the pins; the talus was aligned under the tibia and the proximal ball joint was locked.

The ankle was then distracted and manipulation and the reduction was evaluated fluoroscopically. Then the distal ball for the fixator was locked (the external fixator is AO type as seen in the example picture's).

In 17 cases of our study we performed open reduction using small incision (about 1cm) on the medial aspect of the ankle joint with minimal stripping of the periosteum & using a small bone hook we reduce scattered pieces accurately as much as possible & hold them by multiple k – wires which act as a buttress & a metal secure for fractured articular surfaces (as seen in example 1 & 2 pictuers), the application of k-wires can be done by close reduction under the image intensifier in the remaining three cases.

In the (14 cases) with fibular fractures a percutaneous reduction of fracture & fixation by rush nail (5 cases) or by semicircular compression plate(9 cases) before the fixator applied to restore the length of the fibula ; the patients were allowed to walk with Non weight bearing using walking aids with daily cleaning and caring of pin site & full weight bearing started (4-6) weeks after the operation.

The patients were seen two; four; eight & twelve weeks after discharge from hospital with the use of data sheets at three uniform time periods :-

* The first data sheet completed near the time of discharge from hospital was used to record the initial injury; operative details & post operative care ; any complications ; radiographic data & any problem in wound healing. The reduction of articular surface was

classified on the basis of multiple post operative(ordinary X-ray) radiographs to avoid the high radiological exposure by CT- scann , with modification of the method of burwell & charnley.[8] as in table (2)

Table (2): Classification of reduction of the articular surface of the ankle joint

Location of Displacement		Classification	
	Good	Fair	Poor
Articular			
□ Medial & lat. malleoli	<1.00 mm	1-5 mm	> 5mm
□ Post. malleolus	< 2 mm	2-5 mm	> 5mm
□ Central fragment	< 2 mm	2-5 mm	> 5mm
Talus			
□ Tilt	< 5 mm	5-10	> 10mm
□ Subluxation	< 0.5 mm	0-5 - 2mm	> 2mm
□ Mortise widening	< 0.5 mm	0-5 - 2mm	> 2mm

** The information of second data sheet was collected between 4-6 weeks after injury.. to check for any change in data that has been already collected & check if any further management is needed ; a walking status of patient was noted ; any pin site infection ; ankle movement were measured in maximum planter flexion & dorsiflexion with *goniometer ( )& also subtalar movements were recorded ; also the presence or absence of callus formation & maintenance of both ,,the reduction of articular fracture & angular alignment of the articular surface.

*** The third data was checked out as close to (6 months) after injury: Anteroposterior & lateral radiograph were made & compared with those from second data & check for any signs of osteoarthrosis (which are very likely to happen because of the difficulty of perfect assembling of the multiple fractures fragment).

An ankle score (described by A. kaikkonen ,p. kannus, murukku Ja),[9] was calculated on the basis of the responses to questionnaire combined with clinical data; this 100 point scale allows maximum 40 points for function such as walking and stair climbing & 40 points for pain freedom & 20 points for examination of range of movement of the ankle joint(table 3)

Table 3: Ankle scoring system

Kaikkonen Scale

I Subjective assessment of the injured ankle	
No symptoms of any kind	15
Mild symptoms	10
Moderate symptoms	5
Severe symptoms	0
II Can you walk normally?	
Yes	15
No	0
III Can you run normally?	
Yes	10
No	0
IV Climbing down stairs	
Under 18 seconds	10
18 - 20 seconds	5
Over 20 seconds	0
V Risiing on heels with injured leg	
Over 40 times	10
30 - 39 times	5
Under 30 times	0
VI Rising on toes with injured leg	
Over 40 times	10
30 - 39 times	5
Under 30 times	0
VII Single-limbed stance with injured leg	
Over 55 seconds	10
50 -55 seconds	5
Under 50 seconds	0
VIII Laxity of the ankle joint (ADS)	
Stable (<5mm)	10
Moderate instability (6-10mm)	5
Severe instability (>10mm)	0
IX Dorsiflexion range of motion	
>10°	10
5°-9°	5
<5°	0
Total =	100

>85=Excellent; 70-80=Good; 55-65 = Fair; <50 = poor
From: Kaikkonen A, AJSM, 1994;22: 462

RESULTS

The patients were hospitalized for average of five days & after discharge the patient were allowed to bear partial weight at an average of 4-6 weeks & full weight after

8 -12 weeks. The K – wires usually removed in 4-6 weeks , external fixator was removed at average of 4-6 months & replaced by below knee cast with walking heel or an external brace with walking pad for an average of eight weeks after removal of the fixator. all the patients are healed completely except three patient (case No. 10; case No. 13 & case No. 19) as in figure(5).

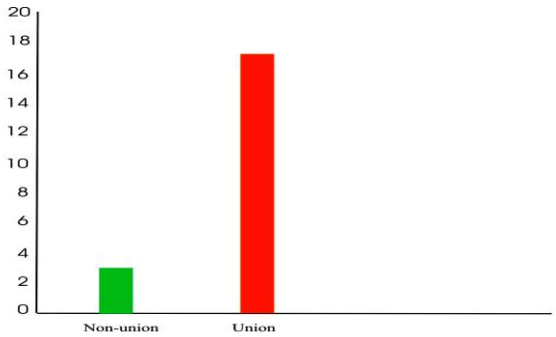

Figure 5: Union Rate

Case No. 10 → had malleolar delayed union at time of the latest follow up examination at 6 months which was later treated by internal fixation by malleolar screw.

Case No. 13 → had supra malleolar Non-union ,its was changed to internal fixation with iliac bone graft.(DCP plate & screws).

Case No. 19 → had in addition to tibial Non-union ; fibular Non union & change to internal fixation & bone grafting for both of them …. about 60% of the cases had good and accepted results regarding the union rate and preservation of the ankle mortise while about 30% ((7 cases))had malunited fractures which need further correction by surgery. Either by supra-malloular osteotomy of the tibiafixed by plat & screw or by using a supra-malloular osteotomy with advance modified illizarove circular multiplanar external fixator called spatal external fixator) as seen in case number one

There were only two cases complicated with infection (tibial osteomyelitis) (case

No. 10 & No. 13) & were treated by proper antibiotics according to culture & sensitivity, also we had nine patients complain from pin site infection which were treated by antibiotics and daily dressing. We have ten cases complicated with sudecks- atrophy which gradually improved with time with proper treatment including physiotherapy, drug treatment for RSDS can include tricyclic antidepressants, non steroidal anti-inflammatories (NSAIDs) and/or corticosteroids, Transcutaneous Electrical Nerve Stimulation (TENS)

There were no infection of the ankle or subtalar joint secondary to external fixator pins & also there was No radiographic evidence of talar necrosis secondary to insertion of the pin in the talar neck.

There were no other neurovascular complications secondary to insertion of fixator pins.

Example of the treated Cases I (No.9):- 30 years old male pharmacist fall from height about five meters on his left lower limb presented with pain & deformity in distal left leg with fracture blisters an X-ray shows distal tibia and fibula fracture (tibial pilon fracture) early management by back slab for three days ; CT-scan done for him which show type C3(AO classification) tibial pilon fracture

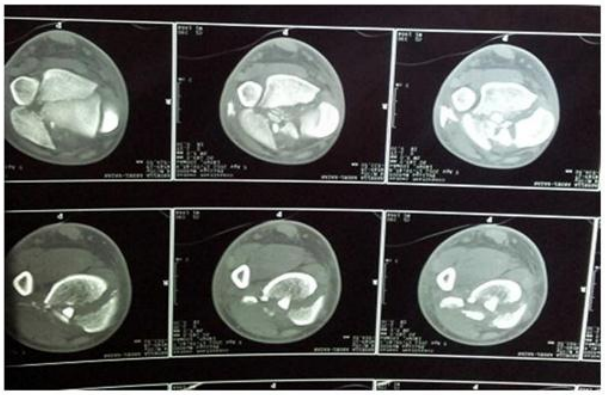

Figure 6: CT-scan and X-ray showing type C3 fracture

Admission to the theater and Spanning external fixation done (distal pins was put in the metatarsal bone because there was liner fracture(crack) in the calcaneum, with multiple K-wires to support the reduction of mortise under screen ; with undisplaced fracture in the fibula, that need no surgical interferances

Figure7: post operative X-ray

Series of follow up X-ray was done ,, after two months the K-wires was removed and after about four months the fixator was removed and put in brace.

Figure 8: X-ray after removal the fixator

To keep the ankle mortise the end result show about 10 degree varus deformity of the ankle j. ; which was corrected by lower tibial osteotomy using (TAYLOR SPATIAL FRAME)for fixation , which is an external device for limb correction, that is based on the ILIZAROV method were the surgeon inputs information about the original bone deformity into an advanced web-based computer application.) the operation was done in Jorden- amman, fellow up by us until the the device was removed after 4 months with full united corrected metaphyseal left tibia

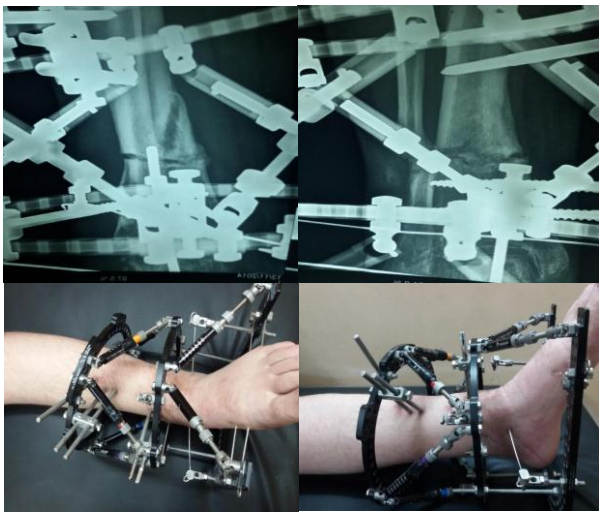

Figure 9: X-rays after corrective osteotomy

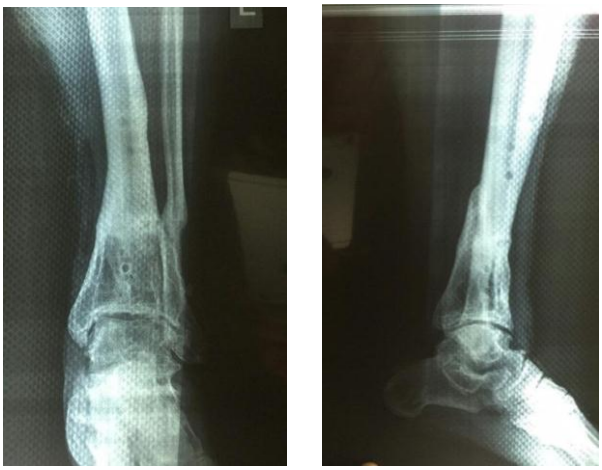

Figure 10: X-rays after the final result

Case no. II(No.13): 40 year old male patient who had motor cycle accident leading to isolated close pilon fracture of the Rt. tibia with soft tissue blisters. X-ray show type C2 tibial pilon fracture

Figure 11: X-ray & Ct-scann of type C2 tibial pilon fracture

Spanning external fixation done with multiple K-wires plus screw fixation throught mini incision

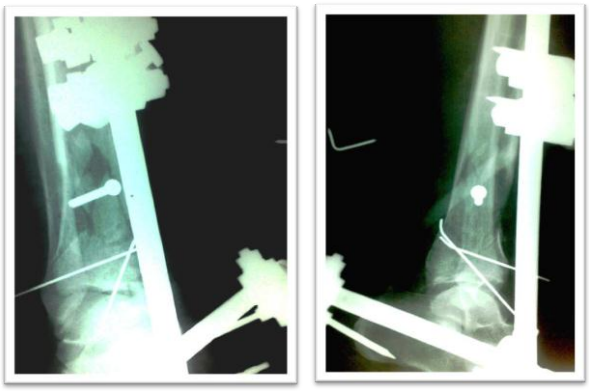

Figure 12: post operative X-ray

Follow up by serial x-ray ,, the K-wiers were removed in two months and after six months the fixation was removed totally and a below knee cast was applied to the leg then replaced by a external brace with walking pad.

Figure 13: Follow up X-ray

Case no. lll.(No.6);- 46 old femal presented with pilon fractuers of the Lt lower leg spanning external fixator across ankle joint with multiple k-wires fixation closed methods to buttress the articular surface & hold the articular fragment together

Figure 14: preoperative x-ray & post operative spanning external fixator applied

Figure 15: Final result X-ray Ap- & Lateral

DISCUSSION

Open reduction and internal fixation of severe multiple fracture of the tibial plafond have been associated with a high rate of complications and difficulty in reduction & it was always a major obstacle for the orthopedic surgeon,[10] as were reported in two studies .. first study by (Mc Ferran) study reported that , twenty one (40%) of fifty two patients.[11] had a major complication(infection , secondary osteoarthritis ,soft tissue necrosis) .while in second study (Teeny SM, Wiss DA),[12] about eleven (37%) of the thirty patients reported to had a deep infection; ..,the large effect of these complications on the outcome of treatment was emphasized in both study due to extensive operative dissection through the poorly vascularized and traumatized soft tissue envelope of the distal aspect of tibia; combined with the complication of implantation a subcutaneous plates ,that why we chose not to do open reduction & internal fixation as we prefer to do spanning external fixation across ankle joint with multiple k-wires fixation to treat the metaphyseal portion of fracture of tibial plafond which has been reported to be associated with a lower rate of wound complications than open reduction & internal fixation.[13,14] This was agreed by " Bonra and Marsh " who found that even temporary periods of external fixation followed by more limited internal fixation resulted in lower wound complications.[15]

The high energy fracture (type B3 & C3according to AO classification) are frequently associated with soft tissue injury in addition to the fractures of the articular surface which could be severely comminuted and despite of secure fixation with plate & screw , collapse of the articular fragment may happen leading to talar subluxation,[16] therefore we thought that across – ankle spanning fixator with multiple k-wires buttressing the articular surface will help so much to control the position of talus with good articular surface fractures reduction during the early stages of healing & could be ideal & the treatment of choice for such fractures; same protocol can be applied to type C1 fractures with variable results as agreed by (DanilN.Ovadia.&RodneyK.) & (Watson Jt.).[17,18]

The external fixation pins are inserted at the hind foot (neck of the talus and the posterior Os of the calcanium)_so to avoid & preserve the neurovascular bundle this explain why we had no neurovascular complication & it help to straddle the subtalar joint & effectively immobilizing it. The first pins required precise care on inserting it at the center of the talar neck once the fixator was assembled.. the decision to

adjust the fixator was made by the surgeon on the basis of angular deviation of the mortise or talar tilt .this was agreed by marthya A.Arun.[19] we had very low rate of infection at the site of pins insertion with no ankle or subtalar joint secondary infection but some sort of loosening of the pins at the time the fixator was removed were detected due to micro movement at the pins insertion when the patient started to put weight in the late stages of healing around 4-6 weeks from the operative day ,,were we have an obvious callus formation on x-ray .in the follow up period .

Adjustment of the fixator was necessary to improve reduction although it was difficult to maintain specially when there was anterior comminution of the distal lip of the tibia ,, that's why we need to secure the reduction of ankle mortise by using multiple K-wires that act as a buttressing plane supporting the comminuted articular surface & help to secure the fracture fragments attached together ,we found that these K-wires play a major role in shortening the healing period with acceptable to good end results .this was agreed by ,Meier C, Schefold JC, Hug U, Trentz O, Platz A. who use Temporary Kirschner wire in ankle transfixation and delayed ORIF & Seibert FJ, Schatz B, Bratschitsch G, Labovitz J, Schippinger G. who used Temporary Kirschner wire ankle transfixation in the treatment of unstable ankle fractures.[19,20] – (i.e.we use the K-wires as a supportive temporary measures that help the definite treatment by spanning external fixator)

There were frequent complications during treatment most of them were managed non-operatively which didn't lead to identifiable long term morbidity as were described & agreed by .Borrelli J, Ellis E.[21] & Harris AM, Patterson BM, Sontich,[22] However; patients should be informed regarding the prognosis. In a study to determine the advantages and disadvantages of plating treatment of the ipsilateral fibular fracture in tibial Pilon fractures treated with external fixation that spans the ankle, (TM Williams et al),[23] found that Open reduction and internal fixation of the fibular fracture in tibial Pilon fractures treated with external fixation spanning the ankle usually associated with a significant rate of complications & a good clinical results may be obtained without fixing the fibula, we found that fixation of a fibula will help to restore the ankle mortis & length if the soft tissue condition was appropriate for internal fixation of fibula .

Conclusions and Recommendations:

1)Pilon fracture is not a common fracture to be seen; n otable more in men than women and it's treatment is a demanding one.

2) Type&Timing of surgery is important and it depend on severity of soft tissue injury.

3) CTscan are extremely useful for determining accurat ely the direction of fracture lines; the size &the displacement of articular fragment & the extent of articular comminution and impaction.

4) Fibular fracture is common with Pilon fracture and it's fixation is mandatory if possible

5) Spanning External fixation is the treatment of choice especially in sever metaphyseal comminution pilon fractures of the lower tibia with supplement of multiple k-wires to hold the reduction & reconstruction of articular surface is the main goal of treatment.

REFERENCES

1. Swiontkowski MF, Sands AK, Agel J, et al. Interobserver variation in the AO/OTA fracture classification system for pilon fractures: is there a problem?. J Orthop Trauma. Oct 2009; (7):467.
2. Tornetta P III, Weiner L, Bergman M, et al: Pilon fractures: Treatment with combined internal and external fixation. J Orthop Trauma 1998;)7(.
3. Teeny SM, Wiss DA: Open reduction and internal fixation of tibial Pilon fractures: Variables contributing to poor results and complications. Clin Orthop 2000 ;292:108
4. Rockwood and Greens fracture in adults (7th edition),chapter 3 p.63
5. Rüedi TP, Allgower M: The operative treatment of intra-articular fractures of the lower end of the tibia. Clin Orthop 1999;138:105- 110
6. Tscherne H, Gotzen L (eds): Fractures with Soft Tissue Injuries. Berlin: Springer-Verlag, 1984.
7. Gustilo RB, Anderson JT: Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: Retrospective and prospective analyses. J Bone Joint Surg Am 1976;58:453
8. burwell & charnley Complications after treatment of tibial pilon fractures: prevention and management strategies. J Am Acad Orthop Surg. Jul-Aug 2000;8(4):253-65.res. Arch Orthop Trauma Surg. Jul 2007;127.
9. Kaikkonen A1, Kannus P, Järvinen M ; performance test protocol and scoring scale for the evaluation of ankle injuries. Am J Sports Med. 1994 Jul-Aug;22(4):462-9.
10. Sirkin M, Sanders R, DiPasquale T, Herscovici D Jr. A staged protocol for soft tissue management in the treatment of complex pilon fractures. J Orth Trauma. Sep 2004;18(8 Suppl)
11. Mc Ferran: Long-term results of tibial Pilon fractures treated with open reduction and internal fixation. Arch Orthop Trauma Surg 2003;110
12. Teeny SM, Wiss DA: Open reduction and internal fixation of tibial Pilon fractures: Variables contributing

to poor results and complications. Clin Orthop 2000 ;292:108

13. Dickson KF , Montgomery S, Field J : High energy plafond fractures treated by a spanning external fixator initially and followed by a second stage open reduction internal fixation of the articular surface preliminary report, injury 32 (suppl D) :92,2001
14. French B1, Tornetta P 3rd ,Hybrid external fixation of tibial pilon fractures Foot Ankle Clin. 2000 Dec;5(4):853-71.
15. John Scolaro, MD , Jaimo Ahn, MD, PhD, In Brief: Pilon Fractures,clinical orth.related reserch . 2011 Feb; 469(2): 621–623.
16. Bonra and Marsh; L, Warnock D, et al. The early management of severe tibial pilon fractures using a temporary ring fixator. Surgeon. Apr 2004;1(2):104 2004;1(1)e498;131
17. Danial N. Ovadia,M.D4, and Rodney K. Beals, M.D.Portland, Fractures of the tibial Pilon Oregon J Bone Joint Surg Am. 2000;68:543
18. Watson JT, Moed BR, Karges DE, Cramer KE. Pilon fractures. Treatment protocol based on severity of soft tissue injury. Clin Orthop Relat Res. Jun 2000;78
19. Marthya A,Arun. B. Biaxial Distraction with Limited Internal Fixation in Pilon Fractures of the Ankle J.Orthopaedics
20. Meier C, Schefold JC, Hug U, Trentz O, Platz A. Temporary Kirschner wire ankle transfixation and delayed ORIF: a staged operative treatment for closed ankle fractures with tibiotalar dislocations and soft-tissue damage. Eur J Trauma. 2004; 30:371–377. doi:10.1007/s00068-004-1021-9 [CrossRef]
21. Seibert FJ, Schatz B, Bratschitsch G, Labovitz J, Schippinger G. Temporary Kirschner wire ankle transfixation in the treatment of unstable ankle fractures. Foot Ankle Surg. 2001; 7:85–92. doi:10.1046/j.1460-9584.2001.00249.x
22. Borrelli J, Ellis E. Pilon fractures: assessment and treatment. Orthop Clin North Am. Jan 2002;33,1..
23. Harris AM, Patterson BM, Sontich JK Results and Outcomes After Operative Treatment of High-Energy Tibial Pilon Fractures Foot Ankle Int vol., 256 - 265, 2006
24. TM Williams, JL Marsh, JV Nepola, TA DeCoster, SR Hurwitz, and SB Bonar External fixation of tibial Pilon fractures: is routine plating of the fibula necessary? J Orthop Trauma, 2002