Medial Platting of Distal Tibial Fractures Why & When?

Zaid W. Al-Shahwanii

ABSTRACT:

BACKGROUND:

Distal tibial fractures , it's an extra-articular distal third tibial fractures that extend for 4-11 cm proximal to tibial plafond , it represent a significant challenge to most of the orthopedic surgeon because the tibial bone is subcutaneously located with poor vascularity & because of the thin & delicate soft tissue covering medially; this may lead to a big conflict on choosing the optimum fixation methods

OBJECTIVE:

To clarify why & when we use a medial plating for distal tibia, explaining the indication ,advantage-disadvantage, surgical procedure & complications.

PATIENTS AND METHOD:

This is a prospective study conducted on 20 patients with distal tibial shaft fracture (15 male and 5 female) with the mean age of 34 years range from (18 y. to 55 y). operated between the periods from January 2015 to July 2016. All were presented with closed distal tibia fractures , treated by open reduction and internal fixation using a DCP plate and screws fixed on the medial surface of the tibia.

RESULTS :

-All patients had a complete union in 4- 6 months except 2 patients (10%) with delayed union. we have 14 cases (70%) with an excellent result, 5 cases (25%) with a good result, one case (5%) end with fair result (6° varus deformity) , we had only one case with superficial infection treated properly & three cases with wound dehisces 15%, 2 patients (10%) developed a delayed union treated with bone graft ..

CONCLUSION :

Open reduction & internal fixation by medial platting for distal tibia fracture using DCP plate, had a biomechanical advantage applying both compression and torsional loading force when used to stabilize varus fracture pattern of distal tibial fracture

KEY WARDS: closed distal tibia fractures , medial tibia plating, and dynamic compression plate.

INTRODUCTION:

Distal tibia fractures represent a significant challenge to most of the surgeons, they constitute 1-10% of all lower extremity fractures [1]. Fractures of the distal tibia (closed lower half of the tibial shaft and extra-articular distal tibial third fractures that extend for 4-11 cm proximal to tibial plafond) are a challenge to treat because of the limited soft tissue coverage & subcutaneous location of the lower tibia with poor vascularity so the best choice of treatment remains controversial[2,3]. Aims of treatment are skeletal stabilization, restoration of length & alignment plus preservation of optimum function, in modern orthopedic techniques a wide variety of options for treatment are present , these are [4,5,6] .either intramedullary nailing or external fixation which are used in a compound fractures , then fixation by Plates and screws ,which need extensive exposure although there are now the new designs of plates, such as locking compression plates with minimally invasive methods of application which give a better fixation stability .[7,8,9]

Head of Trauma & Orthopedic Department
Al-Mustansriya Medical College
Consultant Orthopedic Surgeon
Al-Yarmouk Teaching Hospital.

Table1:Show the advantage & disadvantage of fixation by plate & screws.

Advantages	Disadvantages
Plates • Versatile method of treating upper/lower limb metaphyseal fractures • Good treatment for forearm/humeral diaphyseal fractures Minimally invasive plate designs now available	• Poor results in tibial and femoral diaphyseal fractures • Standard plating technique requires extensive dissection • Plate failure may occur in situations where prolonged union times are expected • Does not easily allow shortening and lengthening • Cannot easily be used in conjunction with external fixation Not suitable alone for defects > 6 cm

In the tibial shaft fracture, the Dynamic Compression Plate (DCP) are commonly used, with screw(either size 3.5 or 4.5mm) fixation in at least six cortices on either side of the fracture site, the screw holes are designed in oval shape to apply axial compression by eccentric screw insertion [10], the tibia is suitable to plate fixation especially along its subcutaneous medial border where it doesn't interfere with the cortical blood supply to the bone inaddatition platting on the flat medial surface of the tibia makes the contouring of the plate more easy than platting on the lateral border, in addition to smaller exposure through the anterior muscles compartment with low risk of injury to the neuro -vascular structure, inferior tibio-fibular joint & syndysmosis that may be damage during fixation of the plat laterally. [11,12,13,14]

With the help of an X-ray taken immediately postoperatively the adequacy of fracture reduction & the anteroposterior alignment was determined by using two radiographic sings (bone gaps & angulation) [15]asfollow;-

excellent reduction <2 mm of the fracture gap and ≤5° of angularly deformity in any plane . Good reduction was regarded as 2 to 5 mm of fracture gap and ≤5° of angularly deformity in any plane.

Fair reduction was regarded as>5 mm of fracture gap or 5°-10^0 of angularly deformity in any plane

Poor reduction was regarded as>5 mm of fracture gap or $>10^0$ of angularly deformity in any plane

The fracture union was consider when there are bone healing of at least 3 of 4 cortices on AP & lateral x-ray examination ,

The most important concern after a tibial fracture treated by plating on medial side is soft tissue healing as it is very sensitive to poor handling. This can be avoided by correct timing surgery , gentle soft tissue handling ,delicate suturing & wound closure without tension , For prophylactic measures antibiotic injection intravenously in a period of 30- 60 minutes before tourniquet inflation and before the incision of the skin [16, 17,18].

Table 2: Modified Klemn and Borner scoring system [14].

Final score	Range of motion	Muscle atrophy	Alignment	Pain	union
Excellent	4	3	4	4	4
Good	3	2	3	3	3
Fair	2	1	2	2	2
Poor	1	0	1	1	1

	Rating
Range of motion of ankle	
No restriction	4
< 25%	3
25-50%	2
50-75%	1
Muscular atrophy (calf)	
No atrophy	3
< 2 cm.	2
2-3 cm.	1
> 3cm.	0
Radiographic alignment	
Normal	4
≤5°	3
5-10^0	2
> 10^0	1
Pain (at the fracture site)	
Absent	4
On prolonged stress	3
On weight bearing	2
At rest	1
Union(weeks)	
< 12	4
13-24	3
25-36	2
> 36	1

PATIENT AND METHODS:

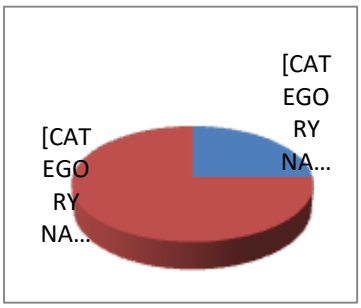
This is a prospective study conducted on 20 patients with tibial shaft fracture between the periods from January 2015 to July 2016 , (15 male and 5 female) with the mean age of (SD± 34 years) range from (18 y.to 55 y).

Inclusion Criteria:

1- Closed displaced tibia fracture at the distal third of the shaft or at the diaphyseal-metaphyseal junction. 2- Skeletally mature. 3- Acute fracture (recent 3-7 days) 4- Unilateral fracture. 5- Closed tibial fracture with grade zero (minimal soft tissue damage) or grade one (superficial abrasion or contusion) as assessed by tscherne classification .

Exclusion criteria:

1- Compound fracture . 2- Fracture complicated with joint involvement such as pilon fracture. 3- Bad soft tissue condition (tscherne classification 3 or more). 4- Pediatric patients. 5- Pathological fractures. 15 patients were male and 5 patients were female as shown in (figure 1) the average age of the participants was 34 years range from (18 years to 55 years)as shown in (figure 2),



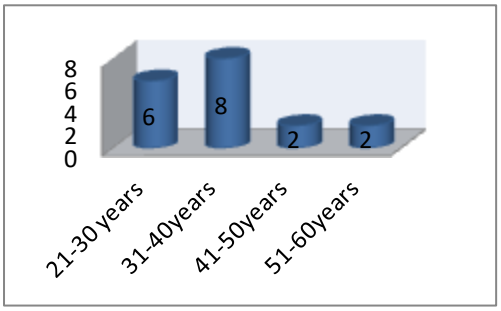


Fig 1: Gender distribution.

Fig 2: Patients' age distribution.

The commonest cause of their injury were road traffic accident (10 patients), and (7 patients) had fall from height injury, and (3patients) had blast injury with blunt trauma to the leg, as shown in (figure 3).(RTA: road traffic accident , FFH: fall from height).

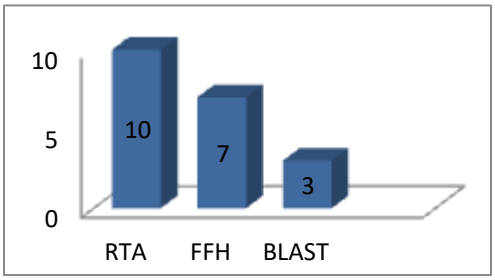


Fig 3: Causes of the fracture.

There were 18 patients presented with fracture tibia and fibula and 2 patients are presented with fracture tibia and intact fibula , the right tibia was involved in 11 patients and the left tibia was involved in 9 patients Indication for medial tibial plating: The statistical analysis was performed; all of the selected patients were divided into 6 groups according to their fracture pattern according to AO fracture classification that direct our decisions for plate fixation on the medial border of the tibia: as in (fig.4) [18 ,19]

1- Simple spiral tibial shaft fracture (42-A1).
2- Simple oblique tibial and fibular shaft fracture (42-A2).
3- Spiral wedge tibial shaft fracture (42-B1).
4- Complex spiral tibial shaft fracture (42-C1)
5- Extraarticular simple distal tibial and fibular fracture (43-A1).
6- Extraarticular wedge distal tibial and fibular fracture—(43-A2).

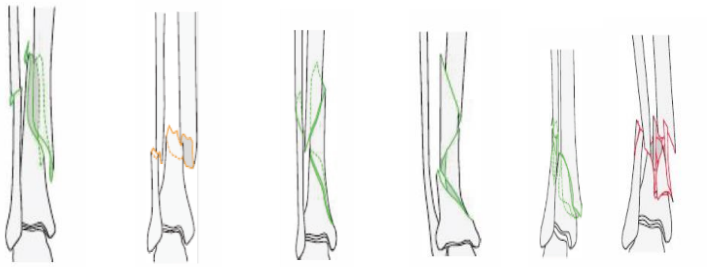


Fig. 4: Types of fractures [18 ,19].

The numbers of our participant in our study and according to previous indications were as follow:

1. Eight patients presented with simple spiral tibial shaft fracture (42A1) which represent (40 %) of patients number.
2. Six patients presented with simple oblique tibial and fibular shaft fracture (42-A2) which represent (30 %) of patients.
3. Three patients presented with spiral wedge tibial shaft fracture (42-B1) which represent (20 %) of patients.
4. One patient presented with complex spiral tibial shaft fracture (42-C1) which represent (5 %) of patients.
5. One patient presented with extra-articular simple distal tibial and fibular fracture (43-A1) which represent (5 %) of patients.
6. One patient presented with Extrarticular wedge distal tibial and fibular fracture—43-A2 which represent (5 %) of patients As seen in (Fig.5)

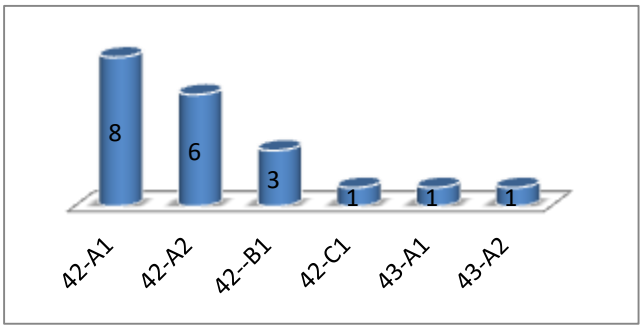


Fig 5: Percentage of fracture types according to AO. Classification.

All patients who sustained a high energy trauma should be managed according to advanced trauma life support guide line , the ABCs protocal :careful assessment of **c**ervical spine injury ,any medical condition as diabetes, asthmatic ,ischemic heart disease ,hypertension . we look for associated injuries in the region**,** and in the distant parts , the injured tissues must be handled gently ,check if there any swelling , bruising and deformity , is the skin intact or not , x-ray examination is mandatory according to the *rule of two* as to complete our examination ,then we stabilize the fracture by back slab of plaster of Paris which was applied in emergency department with elevation to decrease the edema and the pain.

Operative technique ;- In supine position on an operative table with the tourniquet on, perioperative prophylactic antibiotic given intravenously in a period of 30- 60 minutes before tourniquet inflation, through anterolateral approach the incision was made about 1 centimeter lateral to the tibial crest, extending down to the fascia without subcutaneous tissue undermining, the periosteum is gently pushed away for fracture reduction assessment, the Dynamic Compression Plate (DCP) is inserted on the medial border of the tibia with bending (if needed for better anatomical alignment),then six to eight cortices purchases proximal and distal to the fracture site were inserted the tourniquet was decompressed before the closure to obtain a good hemostasis., a good wash with normal saline,then garamycine infusion on the surgical field , closure of the skin with a radi-vac tube drain

Postoperative management: In postoperative period, back slab above knee for the first two weeks with the ankle in 90^0 , broad spectrum intravenous antibiotics were given 3-5 days, active range of movements for the quadriceps muscles strengthening exercises was started on the next day of surgery ,removal of the stitches was done at day 14 , full pop cast applied from below knee joint to the head of the metatarsals for one month with non-weight bearing advice, by the end of the first month partial weight bearing started for two weeks with the cast on ,then the cast replaced by an external brace(boot splint) with full weight bearing and active exercise & a physiotherapy treatment for ankle stiffness this may take from 8-12 week

postoperatively, X-ray evaluation was done with anterio-posterior & lateral view of the tibia done at day one , 4 week ,12 week postoperatively for a collection of data ; the patient asked to be seen at 2week, 4 week, 8 week, and 12 week after removal of the stiches ,the clinical data were analysed by using the modified Klemn and Borner scoring system (table 2) in the four follow up visit from the day of the discharge, 4weeks, 12weeks and 6 months.

Table 3: Patients data.

Patient no.	gender	Age (years)	Type of injury	Type of fracture AO-Class.	Soft tissue condition* Tscherne Clss.
1	Male	18	RTA*	42-A1	Grade 0
2	Female	19	FFH*	42-A1	Grade 1
3	Male	35	RTA	42-A1	Grade 0
4	Male	40	RTA	42-A2	Grade 1
5	Male	22	Blast	42-B1	Grade 1
6	Male	27	RTA	42-B3	Grade 0
7	Female	38	FFH	42-B1	Grade 0
8	Male	50	RTA	42-A1	Grade 0
9	Male	29	RTA	42-A2	Grade 0
10	Male	33	Blast	42-C1	Grade 1
11	Female	36	RTA	42-A1	Grade 0
12	Male	38	FFH	42-A2	Grade 0
13	Male	29	Blast	43-A1	Grade 1
14	Male	20	FFH	42-A2	Grade 0
15	Female	39	FFH	42-A1	Grade 0
16	Male	53	RTA	42-A2	Grade 0
17	Male	55	FFH	42-A1	Grade 0
18	Female	49	RTA	42-A2	Grade 0
19	Male	24	RTA	42-B1	Grade 0
20	Male	26	FFH	42-A1	Grade 0

RTA: road traffic accident. FFH: full from height.
*Soft tissue condition depending on Tscherne classification

The result

The mean healing time was 20 weeks range from (16-24 weeks).
All the patients had complete union at about 6 months except 2 patients (10%) (Case no.9 and case no.13) developed a delayed union that were treated by bone graft application from iliac bone in a second operation.
we have 14 cases (70%) end with an excellent reduction, while 5 cases (25%) end with a good reduction and the last one case (5%) end with fair reduction with 6° varus deformity.
We have only one case of superficial infection (5%) (Case no. 10) that was diagnosed clinically at the first follow-up visit 7 to 10 days postoperatively and treated by hospital admission for few days with intravenously antibiotic & daily dressing until complete recovery .. we have three cases of wound dehisces 15% (case no.8 , case no.13 and case no.17) treated by wound debridement and intravenously antibiotic and daily dressing , the final range of ankle motion at the last follow up visit was from 10 -30 degree dorsiflexion (mean 20 ^{0}) , and 20 – 40 degree plantiflexion (mean 30^0).
The data that was obtained are demonstrated in the table 4 and table 5.

Table 4: Clinical results.

Clinical result	Percentage
Union time	Mean 20 week
Delayed union	10%
Superficial infection	5%
Wound problem	15%
Reoperation rate	20%
Ankle dorsiflexion	Mean 20 ^{0}
Ankle plantiflexion	Mean 30 ^{0}

Table 5: Final resul.

result	Percentage
Excellent result	70%
Good result	25%
Fair result	5%

Case I (NO. 6):27 years old male, with the fracture of the tibia and fibula according to the AO classification (42-B3) fragmented wedge tibial and fibular shaft fracture due to RTA.

Fig 6: Anteroposterior view of the left leg (42-B3) before & after fixation, then after 2 & 4 months respectively

Case II (NO. 16): 53 years old male , had a RTA with fracture tibia & fibula according to the AO classification (42-A2) simple oblique tibial and fibular shaft fracture(fig.20)show before & after fixation & in 4months follow up, then after one years with full union

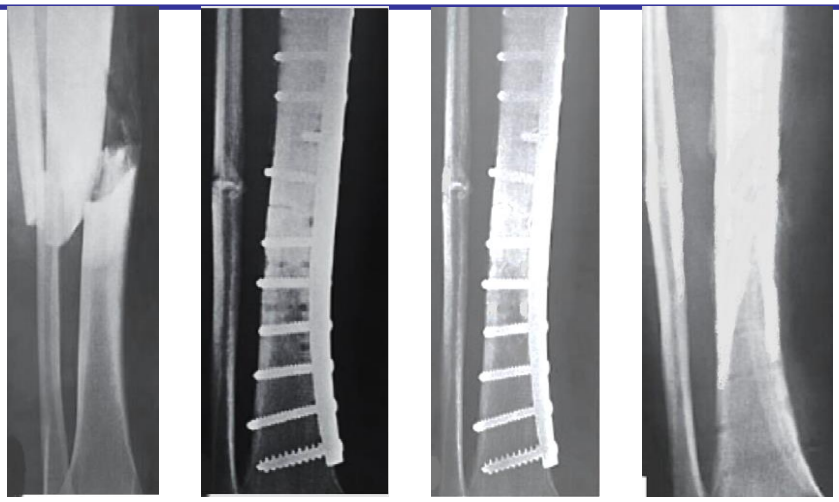


Figure 7: Anteroposterior view of the right leg (42-A2)before & after fixation& in 4months follow up & after removal .

Case III (NO. 18):49 years old female , she had fracture of the tibia and fibula according to the AO classification (42-A2) simple oblique tibial and fibular shaft fracture due to RTA.

Fig 8: Ap.& lat. view of the right leg (42-A2) ,before & after surgery , 6 weeks , 4 months later open reduction and internal fixation by medial tibial plating and screws using the dynamic compression plate.

DISCUSSION:

Distal tibia fractures are still a difficult injuries to be manage when the fracture displacement need surgical treatment , such a fractures consider as one of the most critical types of fractures because of its proximity to the tibial plafond & because the fracture displacement & comminution if present and because of the associated injury to the delicate soft tissue envelope.

The goals of treatment of a distal tibia fracture are ;- anatomical reduction, restoration of axial alignment, maintenance of joint stability, achievement of fracture union with pain free weight bearing and motion , and with no wound complications ,, the treatment plan in a distal tibia fracture depends mainly on fracture pattern depending on (AO classification) , soft tissue injury, patient co-morbidity, fixation resources, and surgical experience.[19]

why we need to do a medial plating for distal fracture tibia because ;-

it give us a very good exposure of the fractures so it help in anatomically & biologically reduction of the displaced fragment with effective stabilization & a good secure internal fixation ,this is in comparison to other methods of management(eg. non-operative pop casting , intramedullary nailing & external fixation) specially if the internal fixation done with careful stripping avoiding the extensive

dissection of periosteum to minimize the risk of soft tissue necrosis due to damage to its vascularity supply which is already jeopardized by the causative trauma , this was agreed and approved by Hooper et al [20] & Jensen JS. et al[21] who found that the non-operative treatment(casting of the distal tibial fracture) result in mal-union and shortening in addition to rotation because of the difficulty to secure the anatomical reduction of fracture fragment , that confirm our decision in planning for platting for the distal tibia instead of pop casting for displaced fracture of distal tibia .
From other point of view fixation by intramedullary locked nail which were discuss by Drosos G, Karnezis IA, Bishay M [22] **,,** Janssen KW, Biert J, van Kampen A, Mosheiff R, Safran O, Segal D, et al [23] who found that intramedullary nail fixation may be less stable & secure in distal tibial fractures with high risk of mal-alignment & rotation leading to non or mal-union this well increase the risk for broken nail & a break of the fixing screw or it may lead to penetration of the nail into the ankle joint due to a large axial shearing & strain between the bone fragments… this fact appprove our study in explaining why we prefer using DCP platting of the distal tibia instead of intramedullary nailing .
On the other hand concerning the use of LCP with minimal invasive plat osteosynthesis (MIPO) , although locking plates have many benefits including fixed angular stability which became more appropriate for elderly osteoporotic patients but they also have some disadvantages as they are vastly more expensive than non-locking plates and it need more
experiences from the surgeons to deal with the presence of CT-arm intra- operatively , it also have a considerable risk of complications as mal-alignment & rotation with improper anatomical fixation as was stated by (MICHAEL WAGNER, ROBERT FRIGG) [24] who describe the pitfall& pearls on using the LCP and LISS plats that the surgeons should be aware of & its complications. this also confirm our decision on using DCP plat for such fractures,

When we do medial platting We found that Medial plating is superior to lateral plating of distal tibia specially when used in varus types of the distal tibial fractuers that was agree by Josef pirolo et al. [25] study who found that (the biomechanical advantage of medial plating for varus fracture patterns) i.e medial plates had a superior biomechanical performance especially in both in compression and torsional loading force with ant-glide mode when compared to lateral plates in varus fracture pattern,. He also stated that in valgus fracture pattern, there was no biomechanical difference between the medial and lateral plating, we found that Josef pirolo et al .. above statement confirm the aim of our study in that the medial plating had superior biomechanical properties especially in a Varus types of fractures (42-A1,42-A2, 42-B1,42-C1 43-A1, 43-A2) according to AO manual for internal fixation [11] .
In our study, we had only three cases (15 %) developed a wound problem and, this is accepted by Lee YS. et al [26] study were he treat (88 cases) with a distal tibia fracture by medially placed plate and screws, they found that a wound problem and symptomatic hardware were a common problem in their studied cases which was about(42.9%) , we thought the minimal soft tissue dissection with preserving of the blood supply with careful wound handling decrease wound problem and a symptomatic hardware. Encinas-Ullan C, Fernandez-Fernandez R, Rubio-Suarez JC, et al**.** [27] reported a superficial infection (9%) in 105 cases with distal tibia fracture treated by medial plating, In our study, we reported only one case (5%) of superficial infection this is because we used a strict sterile instruction with sterile, clean dressing and a good wound can perioperatively and postoperatively.
For union rate Tzeng et al study [28], found the union rate was 27.8 week, while Zelle BA et al [29] in his study, found the union rate was 24.2 week In our study, we found that the average

union rate was 20 weeks range (16-24 week). In general many authors still arguing whether a medial or lateral platting provide a better stability with a good healing rate ,as (Lee et al)[26], (reviewed 88 distal tibia fractures treated with either medial or lateral plates and found significantly lower complication rates and fewer hardware problems with lateral plating) . while Yenna's [30], group found(on simulated tibial loading there are no significant difference in mean stiffness between medial and lateral plates). Encinas-Ullan& colleagues[27] on other hand in a prospective study of (40 patients treated with medial versus lateral plating) they found that there are no statistical differences considering time to union and rates of infection, declaring that tibial medial plating have a good fractures exposure when accompanied with careful soft tissue tickling & dissecting this agreed with our conclusion in our study.

CONCLUSION AND RECOMMENDATION:

1-The surgeon should carefully observe the fracture pattern and the resulted deformity with the soft tissue condition in order to decide timing of surgery & whether to use medial or lateral plating.

2- The medial plates had a biomechanical advantage especially in both a compression and torsional loading force when used to stabilize varus fracture pattern of distal tibial fracture where it act as anti-glide plate

REFERENCES:

1. Court-brown CM, Caesar B. Epidimiology of adult fracture: a review injury 2006; 37:691-69.
2. Last R.J. ,Anatomy regional and applied. Chrchill Livingstone, Edinburg. 7th ed.1984, 199-203
3. Richard S. Snell, clinical anatomy for medical students 31×1 edition. Boston-Tornto.1986.pag 898-920.
4. Michael W. Chapman, et al. , CHAPMAN'S ORTHOPAEDIC SURGERY, principle of internal and external fixator,3rd edition, Philadelphia, Lippincott Williams & Wilkins 2001;11
5. ANAND J. THAKUR: The elements of fracture fixation, Bone Screws, Second Edition, New Delhi –India, Elsevier;2007:38.
6. Robinson CM, McLauchlan G, Christine J, McQueenMM, Court-Brown CM. Tibial fracture with bone loss treated by primary reamed intramedullary nailing. J B JSurg [Br] 2009; B: 906-13.
7. Gautier E, Sommer C Guidelines for the clinical application of the LCP. Injury; 2003;34:63–76.
8. Wagner M General principles for the clinical use of the LCP. Injury; 2003;34:31–42.
9. Michael Wagner, AO Manual o f Fracture Management Internal Fixators Concepts and Cases using LCP, Switzerland.2006; 684-85.
10. S. TERRY CANALE,JAMES H. BEATY:Campbell's operative orthopedic: surgical approach's, twelfth edition, Philadelphia, Elsevier Mosby; 2013:32
11. Müller, M.E., Allgöwer, M., Schneider, R., Willenegger, H. Manual of INTERNAL FIXATION Techniques Recommended by the AO-ASIF Group , third edition ,springer-verlag berlin.2014:45.
12. IM Anuar-Ramdhan, IM Azahari, M Med Orth, Minimally Invasive Plate Osteosynthesis with Conventional Compression Plate for Diaphyseal Tibia Fracture, Malays Orthop J. 2014;8:33–36.
13. F. Baumgart ,J. Buchanan, J. A. Disegi , R. Hertel ,A. Murphy ,S.M. Perren: AO/ASIF Instruments and Implants, Plates for Large Bone Fractures , Second Edition, German, Springer-Verlag Berlin: 2011;87.
14. Ganesan G. Ram*, Deebak Kumar, Vijayaraghavan V. Phagal,Surgical dilemma's in treating distal third leg fractures,International Surgery Journal,Ram GG et al. Int Surg J. 2014;1:13.
15. sarminto A, Latta L.functional fractuers bracing.JAmA cad Orthop surgery 1999:7-66-75.
16. Perren SM. Evolution of internal fixation of long bone fractures: the scientific basis of biological internal fixation: choosing a new balance between stability and biology. J Bone Joint Surg [Br] 2002; 84-B: 1093-110.
17. Egol KA, Weisz R, Hiebert R, Tejwani NC, Koval KJ, Sanders RW. Does fibular plating improve alignment after intramedullary nailing of distal metaphyseal tibia fractures? J Orthop Trauma 2006;20:94-103. Back to cited text no. 8
18. Müller ME, Nazarian S, Koch P , The Comprehensive Classification of Fractures of Long Bones. (1990) 1st ed. Berlin Heidelberg New York: Springer-Verlag.
19. Jason W Busse, Emily Morton, Christina Lacchetti, Gordon H Guyatt & Mohit Bhandari;Current management of tibial shaft fractures: A survey of 450 Canadian orthopedic trauma surgeons; Journal Acta Orthopaedica , 2008;79: 689-94.
24. Hooper GJ, Keddell RG, Penny ID. Conservative management or closed nailing for tibial shaft fractures. A randomized prospective trial. J Bone Joint Surg Br. 1991;73:83-85.
25. Jensen JS, Hansen FW, Johansen J. Tibial shaft fractures. A comparison of conservative treatment and internal fixation with conventional plates or AO compression plates. Acta Orthop Scand. 1977;48:204-12.
26. Janssen KW, Biert J, van Kampen A. Treatment of distal tibial fractures: plate versus nail: a retrospective outcome analysis of matched pairs of patients. Int Orthop. 2007; 31:709-14.
27. Drosos G, Karnezis IA, Bishay M, et al, Initial rotational stability of distal tibial fractures nailed without proximal locking: the importance of fracture type and degree of cortical contact. Injury 2001; 32:137–43.

28. MICHAEL WAGNER, ROBERT FRIGG Internal Fixators: Concepts and Cases using LCP and LISS, Hardback Thiem, publisher (Stuttgart), 2006:868.

29. Josef pirolo,Anthony behn, Geoff Abrams, Julius bishop; anterolateral vs. medial plating for distal extraarticular tibia fracture, September 2015;38 :e760-e765.

30. Lee YS, Chen SH, Lin JC, et al. Surgical treatment of distal tibia fractures: a comparison of medial and lateral plating. Orthopedics. 2009;32:163.

31. Encinas-Ullan C, Fernandez-Fernandez R, Rubio-Suarez JC, et al. Medial versus lateral plating in distal tibia fractures: a prospective study of 40 fractures. Rev Esp Cir Ortop Traumatol. 2013;57:117–22.

32. Tzeng HM ,Yang SW,Chou YJ, Teng HP, Liu HH, Wong CY. Treatment of distal tibial metaphyseal fractures: Plating versus shortened intramedullary nailing. Injury 2006; 37:531-35.

33. Zelle BA, Bhandari M, Espiritu M, Koval KJ, Zlowodzki M; Evidence-Based Orthopaedic Trauma Working Group. Treatment of distal tibia fractures without articular involvement: a systematic review of 1125 fractures. J Orthop Trauma. 2006;20:76-79.

34. Yenna ZC, Bhadra AK, Ojike NI, et al. Anterolateral and medial locking plate stiffness in distal tibia fracture model. Foot Ankle Int. 2011;32:630–37.