Basrah Journal

Of Surgery

Bas J Surg, September, 14, 2008

SOFT TISSUE RECONSTRUCTION IN SEVERE OPEN LEG FRACTURES (GUSTILO TYPE III)

Mahmood A Mahmood[*], Ali H Khudair[#] & Zuhair F Fathallah[@]

*MBChB, Basrah General Hospital. [#]FICMS, Assistant Prof. of Orthopedic surgery, Dept. of Surgery, Basrah College of Medicine. [@]MSc, Assist.Prof.of Plastic Surgery, Dept. of Surgery, Basrah College of Medicine.

Abstract

Eighteen patients who sustained severe open leg fractures (Gustilo's III) were treated in AL-Basrah General Hospital and Al-Sadder Teaching hospital between 2007 and 2008. They were12 males and 6 females, average age were 25 years. Middle third fractures occurred in 8 cases (44.4%) and the comminuted geometry of fracture was in 14 patients (77.7%). All patients were treated by meticulous wound excision with stabilization of fracture and then wound cover, which is done early in 6 patients (before 7 days) and late in 12 patients (after 7 days). Local muscle flap was done in 9 patients (50%), local fasciocutanous flap in 6 patients (33.3%) and free flap in 3(16.7%). The complications occurs more in late local reconstruction as flap infection in (55.5%), nonunion in (33.3%), flap necrosis in (22.2%) and osteomylitis in (33.3%) while in early reconstruction it is found only (16.6%) as a complication of each of the above. In muscle flap, flap infection found in (22.2%), flap necrosis in (11.1%) and nonunion in (22.2%) which was lower than other type of reconstruction, the muscle flap was more reliable flap in early period of reconstructions. In conclusion, primary reconstruction of Gustilo's type III open tibial fractures had advantages compared with secondary reconstruction.

Introduction

One of the most important goals in the treatment of severe injury of the tibia is to obtain adequate soft-tissue coverage. Soft-tissue coverage procedures are performed to provide a closed wound to promote re-vascularization of the injured bone and soft tissue and to prevent infection and nonunion that may occur secondary to persistent bone ischemia. The type of the covering used for soft tissue defect is generally chosen on the basis of anatomical considerations, specifically the location of the defect on the leg, the size of the defect, and the availability of local tissues for covering[1,2]. Numerous studies have demonstrated that compound fractures are best managed by aggressive early wound debridement, rigid orthopedic fixation and definitive wound closure by plastic surgical means, if necessary, ideally within the first 7 days of injury[3]. Because of the advances in wound care over the past two decades, soft-tissue coverage is less of a limiting factor in limb salvage. Before the development of microsurgical techniques, treatment of severe lower extremity wounds was often amputation or skin grafting. In complex wounds, skin grafts gave inadequate results because of the difficulty of healing over

exposed bone, leading to high rates of osteomyelitis and amputation. In the late 1980s to early 1990s, micro vascular free-tissue transfer became routine for salvage of traumatized extremities, allowing surgeons to reconstruct severe Gustilo grade III open fractures. Many centers began to reconstruct the majority of grade III fractures with free-tissue transfer. However, free flaps represent the highest rang on the reconstructive ladder, requiring technical capability; it is costly and time-consuming operations, with significant complication rates, donor-site morbidity, and failure rates[4]. The options for coverage of traumatic soft-tissue defects about the tibia that cannot be managed by direct closure include local flaps and free flaps. Muscular flaps for coverage of such soft-tissue defects include gastrocnemius and soleus muscle flaps, myocutaneous flaps, fasciocutaneous flaps, cross-leg flaps, and variations there of .The basic idea behind these procedures is that the presumed healthy tissue is rotated on a vascular pedicle to provide a coverage to the zone of injury and a fresh source of blood. Conversely, free flaps typically are harvested from an area remote to the zone of injury, and their vascular supply is provided by means of micro vascular anastomoses[5]. Other authors have recommended gastrocnemius rotational flaps for defects over the proximal third of the tibia, soleus rotational flaps for defects over the middle third and free flaps for defects over the distal third. Others have postulated that the timing of coverage is more important than the type of flap and that flap coverage should be performed in less than seven days after the injury to decrease the chances of complications such as osteomyelitis and flap infection[5]. Although free-tissue transfer is a vital component of limb salvage, advances in wound care technology and better understanding of local flap design have provided increasing options for soft-tissue reconstruction of the severely injured lower extremity[4]. Greater experience with local lower extremity flaps, including the sural flap and soleus flap, has demonstrated their versatility for the reconstruction of lower leg defects[4]. Motor vehicle accidents, skiing accidents, and high-energy falls are the common causes. The mechanism of injury determines the fracture configuration (e.g., skiing injuries typically cause spiral fractures). Most fractures are comminuted. Pedestrians who are hit in the upper and middle one third of the tibia sustain bumper injuries. Distal tibial and plafond tibial fractures are the most common long bone fractures of the body skeleton[6]. Blast injury is the most common form of injury in recent military campaigns and in civilian terrorist attacks. Most orthopedic trauma is caused by the secondary effect of blast penetrating fragment injury[7].

Options in Soft Tissue Reconstruction:

With a better understanding of wound physiology most acute wounds today can be successfully managed and closed. This spares the patient time, costs, and speeds rehabilitation, prevents squeal of chronic wounds, obviates the development of chronic infection .Indications for mandatory wound coverage include exposed vessels, nerves, bone, tendons or prosthetic material; in other words, the situations most likely to be found in a severely injured limb[8]. The choices for soft tissue covering are: Allow healing by secondary intention, Delayed primary closure, Skin grafts, Local flaps, free tissue transfer and VAC devise. Flap choice in our series was largely determined by the demands of the defect, but there are some considerations germane to the pediatric patient. The

Latissimus dorsi muscle was the flap of choice in the majority of cases, as it has a consistent vascular anatomy and a vascular pedicle of sufficient caliber, even in very small children[9].

Patients and Method:

This study is a prospective comparative study conducted on 20 patients (14 male and 6 female) their age were ranging from (4-53) years, with severe open leg fracture resulting from high energy injuries. All patients dealt with in orthopedic and plastic departments in Al-Basrah General Hospital and Al-Sadder Teaching Hospital respectively, during the period from February 2007 till April 2008. Our patients were evaluated by detailed history, thorough physical examination with radiological and other laboratory investigation to assess the injury and to exclude other associated injuries. Only Gustilo type III fractures were included in our study others were excluded. Three patients were Gustilo IIIc; two of them were excluded from this study because of amputation as a result of the massive injury from the start, and the third one end with non union.

After stabilization of the patients general condition, wound debridement was done under general anesthesia, fixation of the fractures were done either by internal fixation (plate and screw, K nail), external fixation (AO type, Hoffman or Illizarov) or P.O.P, then the wound closed either early (before 7 days) or late (after 7 days) according to situation of wound, degree of contamination, availability of flap, the time till the patient reach to our department and general conditions of the patients.

The types of the flap used are gastrocnemius muscle and saphenous flap in upper third defect, medial hemisoleus, medial gastrocnemius and saphenous flap in middle third defect, while in lower third defect, free flap (Latissimus dorsi muscle) saphenous and lateral suprmalleolar flap. Bone losses (which are found in 6 patients) were dealt with by either primary or secondary bone graft (cancellous, cortical or combined bone graft) or by carrying segment.

Post operatively, the injured limbs were maintained in elevated position, all patient received paranteral antibiotics (third generation cephalosporin and Metronidazle). The alignment and healing of bone and soft tissue were fallowed by clinical examination with frequent change of dressing and serial radiograph every 2-4 week; patients were followed up every other week for three months, then monthly till end of study for 12-16 months.

Results

Eighteen patients with compound fracture tibia (Gustilo's type III) were treated. The average age of the patients was 25 y, ranging from 4-53 years (Table I).

Age in year	Number of patients	Percent
1-10	5	27.8
11-20	1	5.6
21-30	6	33.3
31-40	2	11.1
> 40	4	22.2
Total	18	100%

Table I: Distribution of patients according to age.

Twelve patients with open tibial fractures were male representing 66.7%, and the remaining 6 were female which forms 33.3%. Male to female ratio was 2:1. The level of injury; middle third of leg was involved in 8 patients (44.4%), while the upper and lower thirds involved in 5 (27.8%) each and the shape of the fracture was comminuted in 14 (77.9%) of patients (Table II).

Level of injury	Comminuted No. %	Transverse No. %	Oblique No. %	Total No. %
Upper third	4 (22.3%)	1 (5.5%)	0 (0%)	5 (27.8%)
Middle third	5 (27.8%)	2 (11.1%)	1 (5.5%)	8 (44.4%)
Lower third	5 (27.8%)	0 (0%)	0 (0%)	5 (27.8%)
Total	14 (77.9%)	3 (16.6%)	1 (5.5%)	18 (100%)

Table II: Distribution of patients according to level of injury and shape of fracture.

Mechanism of injury (MOI); missile injury was the cause in 7 patients (38.9%), road traffic accidents (RTA) in 6 (33.3%), gun shot in 4 (22.2%) and fall from height (FFH) in 1 (5.6%) (Table III).

MOI*	Number of patients	Percent
Missile(high velocity)	7	38.9
RTA*	6	33.3
Gunshot(low velocity)	4	22.2
FFH*	1	5.6
Total	18	100%

*MOI=Mechanism of injury, RTA= road traffic accident, FFH= fall from height
Table III: Distribution of patients according to mechanism of injury.

Eighteen patients with open tibial fractures were treated, 17 patients (94.5%) were found to be Gustilo's type III b, and in one patient was type III c (5.5%).

The primary surgical procedures that were done for the 18 injured patients were wound debridement (W.D.) in 8 patients (44.5%), W.D. and fixation in 6 patients (33.3%) and W.D., fixation and early soft tissue reconstruction in 4 patients (22.2%).

Local muscle flap was done in 9 patients (50%), local fasciocutanous flap in 6 patients (33.3%) and free flap in 3(16.7%). Early local soft tissue reconstruction was done in 6 patients (33.3%) including fasciocutanous flap (11.1%) and muscle flap (22.2%) while late reconstruction done in 12 (66.7%) which included 9 local and 3 free flaps, the local muscle flap are more reliable flap in early period of reconstruction (Table IV).

Time of reconstruction	Local F-C Flap* No. %	Local M Flap* No. %	Free Flap No. %	Total No. %
Early <7 days	2 (11.1%)	4 (22.2%)	0 (0%)	6 (33.3%)
Late > 7 days	4 (22.2%)	5 (27.8%)	3 (16.7%)	12 (66.7%)
Total	6 (33.3%)	9 (50%)	3 (16.7%)	18 (100%)

M Flap=muscle flap. F-C Flap=fasciocutanous flap.
Table IV: Time and the type of the soft tissue reconstruction.

The complications were found higher in late local reconstruction, 5 patients out of 9 with late reconstruction end with flap infection which represent (55.5%), nonunion in 3 (33.3%), flap necrosis in 2 (22.2%) and osteomylitis in 3 (33.3%). While in early reconstruction there was only 1 patient (16.6%) as a complication of each of the above (Table V).

Type of re-construction	Number of patients	Flap infection No. %	Non-union No. %	Flap necrosis No. %	Osteomylitis No. %
Early Local Flap	6	1 (16.6%)	1 (16.6%)	1 (16.6%)	1 (16.6%)
Late Local Flap	9	5 (55.5%)	3 (33.3%)	2 (22.2%)	3 (33.3%)

Table V: Relation between early and late local reconstruction and complication.

Regarding non union, it's found that in lower third injury it's higher than other level, 3 of the 5 patients (60%) end with non union. In upper third fractures only 1 patient out of 5 ended with non union (20%) and in the middle third it's also occurring in 1 patient (12.5%) (Table VI).

Level	No. of patients	No. of non union	Percent
Upper third	5	1	20
Middle third	8	1	12.5
Lower third	5	3	60

Table VI: Relation between level of injury and non union of tibia.

Flap infection found in 2 patients from the 9 (22.2%), flap necrosis in 1(11.1%) ,non union in 2 (22.2%) and osteomylitis in 1(11.1%) which was lower than those with fasciocutanous flap in whom flap infection was in 4 (66.6%),flap necrosis in 2(33.3%) , non-union in 2(33.3%) and osteomylitis in 2(33.3%) respectively (Table VII).

Type of reconstruction	No. of patients	Flap infection No. %	Flap necrosis No. %	Non union No. %	Osteomylites No. %
Muscle flap	9	2 (22.2%)	1 (11.1%)	2 (22.2%)	1 (11.1%)
Fasciocutanous flap	6	4 (66.6%)	2 (33.3%)	2 (33.3%)	2 (33.3%)
Free flap	3	1 (33.3%)	1 (33.3%)	1 (33.3%)	1 (33.3%)

Table VII: Relation between type of soft tissue reconstruction and flap infection and non union.

Seven patients were found to be smokers, those had higher incidence of complication than the non smoker group (Table VIII).

smoking	No. of patients	Flap Infection No. %	Non union No. %	Flap necrosis No. %	Osteomylitis No. %
+ve	7	4 (57.1%)	3 (42.8%)	2 (28.5%)	2 (28.5%)
-ve	11	3 (27.2%)	2 (18.1%)	2 (18.1%)	2 (18.1%)

Table VIII: Relation between smoking and complication

Type of reconstruction; in upper third defect, medial gastrocnemius flap was done in 2 patients (11.1%), lateral gastrocnemius flap in 1 (5.6%) and saphenous flap in 2 (11.1%). In middle third defect, medial hemisoleus flap was done in 4 patients (22.2%), medial gastrocnemius flap in 2 (11.1%) and saphenous flap in 2 (11.1%), while in lower third defects, free flap was done in 3 (16.6%), saphenous and lateral suprmalleolar flap were used in two patients, 1 for each (5.6%) (Table IX).

Injured site	**Medial Gastro. No. %**	**lateral Gastro. No. %**	**Medial hemisoleus No. %**	**Saphenous No. %**	**Lateral suprmall No. %**	**Free flap No. %**	**Total No. %**
Upper third	**2 (11.1%)**	**1 (5.6%)**	**0 (0%)**	**2 (11.1%)**	**0 (0%)**	**0 (0%)**	**5(27.8%)**
Middle third	**2 (11.1%)**	**0 (0%)**	**4 (22.2%)**	**2 (11.1%)**	**0 (0%)**	**0 (0%)**	**8(44.4%)**

Lower third	**0 (0%)**	**0 (0%)**	**0 (0%)**	**1 (5.6%)**	**1 (5.6%)**	**3(16.6%)**	**5(27.8%)**
Total	**4 (22.2%)**	**1 (5.6%)**	**4 (22.2%)**	**5 (27.8%)**	**1 (5.6%)**	**3(16.6%)**	**18(100%)**

Chi-square=0.223 p-value=0.148

Table IX : Relations between site of injury and types of reconstruction flaps.

Discussion

The goal of open fracture management is to decrease complications and to obtain an anatomic, functional limb. This study once again confirms the importance of early soft tissue cover following radical debridement and rigid fixation.

Eighteen patients with compound fracture tibia (Gustilo's IIIb & c) were managed,. The average age was 25 y (ranging from 4-53 years). A study done by Chittoria R., Mishra SM.[10] shows that 65% of cases were between 20-30 years.

This study shows that 66.6% of patients were male and the remaining 33.3% were female. Shinzawa H., Yamada N., Shindo M.,et al[11] shows the same percentage, and Egol, K., TejwaniN., Capla, E., et al[12] shows that 79 % were male and 21% were female. The reason for male predominance is that most of the workers are male in their active age between 20-30 years.

Regarding mechanism of injury (MOI), missiles were the cause in 38.9% of patients, road traffic accidents (RTA) in 33.3%, gun shot 22.2% and fall from height (FFH) 5.6%. These results are similar to a study done by Yoram A Rami M., and Meir L. G.Fenelon[7] which shows that the missile injuries to the extremities is the most common form of injury in recent military campaigns and in civilian terrorist attacks, which is similar to the situation in our country now. On the other hand, Rakesh K., Marcus T., G.Fenelon.,et al.[3] shows that (RTA) are the most common form of injury fallowed by work injury and then gun shot injury.

The level of injury was higher in the middle third 44.4 %, but in both upper and lower third it was 27.5%. Muhannad S[13] shows that 53% of patients were injured in the middle third and 23.5% in both upper and lower third, Chittoria R., Mishra SM[10] shows that the higher percentage were in the lower third 60% , followed by middle third 25% and upper third 15% .

As for the pattern of fracture, this study shows that 77.7% of the injuries were comminuted fractures, same results shown by Azam Q., Sherwani MKA., Abbas M.,et al[14].

Regarding The Gustilo's classification, 94.5% of patients in this study were classified as type IIIb and the remaining 5.5% as type IIIc, a study done by R. Hertel, S. M. Lambert, S. Müller et al[17] shows a series of 29 patients were divided as 24 IIIb and 5 IIIc. The lower number of type IIIc may explained by the high percentage of patients ended with amputation.

High percentage of the primary surgical procedures were wound debridement (W.D.) which is done in 44.5%, a similar study done by Azam Q.,

Sherwani MKA., Abbas M.,et al[14] shows that aggressive debridement were performed as a primary surgical procedures in majority of the patients. In our locality the condition of emergency theater at night is very poor and nothing more can be done than W.D. Sometimes multiple wound debridements (W.D.) have to be done during the first week.

Concerning type of flap, higher percentage of flaps were local muscle flap, which is done in 50% of patients, local fasciocutanous flap in 33.3%, and free flap in 16.7%. Also its shows that the local muscle flaps are more reliable flap in early period; this result goes well with a study done by Hallock, Geoffrey G. MD[15], which shows that higher percentages were the local muscle flap. The local muscle flap is more reliable flap in early period of reconstructions; perhaps the force of the trauma may disrupt essential fascial perforators which are important in local fasciocutanous flap.

The early reconstruction had lower percentage of complications regarding flap infection, nonunion, flap necrosis and osteomylitis compared to late reconstruction. Same results found in a study done by Godina[16], which shows that the primary closure results in less complications, better postoperative results, than secondary soft tissue reconstructions which has a higher incidence of flap complications and osteomyelitis. The result is similar to a study done by R. Hertel, S. M. Lambert, S. Müller et al[17], which suggest that immediate reconstruction, if the general condition of the patient permis, is the treatment of choice for soft-tissue coverage. Another study done by Hrvoje Š. Zeljko F., Darko Ekl.,et al[1] shows that the primary reconstructions are the treatment of choice and should be chosen whenever the general condition of the patient and surgical facility permit its use.

The percentage of non-union in relation to the site of fracture was 60% in the lower third, 12.5% in the middle third and 20% in the upper third that means it is higher in the lower third, which is entirely surrounded by tendons rather than richly vascular muscles. Hoppenstal et al[18] found that fracture in the lower third of tibia is one of the important factors in developing non-union. Al-Edany[19] found that the incidence of non-union was higher in the distal third of tibia. Poor blood supply, insufficient soft tissue cover and size of defect are responsible for increasing number of non union cases in this level. But in a study done by Hoagland and States[20], they found that the level of fracture has no significant effect in the prognosis, but the amount of bony contact has.

As for the type of soft tissue reconstruction, this study shows that the muscle flap had lower percentage of complications in relation to other type of reconstruction, that goes with a study done by Hallock, Geoffrey G. MD[15] which shows also that the muscle flap had lower percentage of complications than other types, this is because muscle flaps had an important role in eliminating dead space potentiality for infection, and enhance the immunologic milieu by improving vascularity and oxygen delivery to the contaminated wound.

Type of reconstruction; in upper third defect, gastrocnemius muscle and saphenous flaps were done. In middle third defect, medial hemisoleus, medial gastrocnemius and saphenous flaps were done, while in lower third defect free, saphenous and lateral suprmalleolar flaps were used, this agrees with R.Hertel, M.D[21] who found that the three most useful regional flaps for the knee and the proximal third of the leg, are the medial gastrocnemius, the lateral gastrocnemius, the saphenous flap. In the middle third, the medial hemisoleus and the saphenous flap are preferred. In the distal third, the lateral suprmalleolar. Also study done by Andrew N., Pollak M.D., Melissa L. et al[5] which recommended gastrocnemius rotational

flaps for defects over the proximal one-third of the tibia, soleus rotational flaps for defects over the middle third and free flaps for defects over the distal third.

This study shows that the Smoking group of patients had higher incidence of complication than the non smoker group, this result confirmed by a study done by Adams CI., Keating JF., Court-brown CM[22], they found that flap failure was higher, bone healing was slower and rate of non- union was higher in the smoking group. The smokers had gained less (or lost more) weight, had poorer health, less immunity, ischemia because of microangiopathy effect on small blood vessels and then interfere with the normal processes of flap and bone healing .

Conclusion

1-Early reconstruction had a lower percentage of complications regarding flap infection, nonunion, flap necrosis and osteomylitis in relation to the late reconstruction and should be chosen whenever the general condition of the patient and surgical facility permit its use, in order to convert the open fractures to closed one and then doing further steps of operations such as internal fixation, bone grafting and decrease risk of infection.

2-Muscle flap had lower percentage of complications in relation to other type of reconstruction because an important role to eliminate dead space which is potential for infection, improving vascularity and oxygen delivery to the involved area.

References

1- Hrvoje S., Zeljko F., Darko E., et al., Primary vs Secondary Wound Reconstruction in Gustilo Type III Open Tibial Shaft Fractures. Croatian medical journal 2003; 44(6):746-755.

2- Browner BD., Jupiter JB., Levine AM., et al., Skeletal trauma. Browner BD. fractures, dislocations, ligamentous injuries.2nd ed. Philadelphia (PA) 1998: Saunders; pp.391-418.

3- Rakesh K., Marcus T., G.Fenelon., et al., Management of compound fractures: The Crucial timing of soft tissue coverage by early plastic surgical intervention.. Journal of Bone and Joint Surgery 1999; 72B; 801-804.

4- Parrett., Brian M. M.D., Matros., et al., lower extremity Trauma: Trends in the Management of Soft-Tissue Reconstruction of Open Tibia-Fibula Fractures. Journal of Plastic and Reconstructive Surgery 2006; Volume 117(4), pp 1315-1322.
5- Andrew N., Pollak M.D., Melissa L.,et al., Short-Term Wound Complications after Application of Flaps for Coverage of Traumatic Soft-Tissue Defects About the Tibia. Journal of Bone and Joint Surgery 2000; VOL. 82-A, NO. 12.
6- Minoo P., Jolm H., Tibia Fractures, Open; March 30, 2007 www.emedicine com/orthoped/topic 336.
7- Yoram A., Rami M., Meir L., Blast and Penetrating Fragment Injuries to the Extremities. Journal of American Academy of Orthopaedic Surgery 2006; Vol 14, No 10, S136-S139.
8- Lee Theophelis, M.D., Soft Tissue Reconstruction in Limb Salvage. (1998); July 22, 2007: Jacksonville Medicine, dcm@dcmsoline.org.
9- Rinker., Brian M.D.,Valerio.,et al., Micro vascular Free Flap Reconstruction in Pediatric Lower Extremity Trauma: A 10-Year Review. Journal of plastic and reconstructive Surgery 2005; Volume 115(6), pp 1618-1624.
10- Chittoria R., Mishra SM., Fasciocutaneous flaps in reconstruction of lower extremity: our experience, Kathmandu University Medical Journal 2004; Vol.2, No. 4
11- Shinzawa H., Yamada N., Shindo M.,et al. Early Soft Tissue Reconstruction of the Open Tibial Fractures. Journal of Nippon Gekakei Rengo Gakkaishi 1999; VOL.24; NO.6; pp.905-909.
12- - Egol, K., TejwaniN., Capla, E., et al, Staged Management of High-Energy Proximal Tibia Fractures (OTA Types 41): The Results of a Prospective, Standardized Protocol, Journal of orthopaedic trauma 2005; Volume 19(7), August, pp 448-455
13- Muhanned s., the incidence of non-union after missile Gustilo III tibial fracture. Thesis for Iraqi Board degree in fractures and orthopaedic surgery 2006; P 13, 16.
14- Azam Q., Sherwani MKA., Abbas M.,et al, Internal fixation in compound type III fractures presenting after golden period , Indian Journal of Orthopaedics 2007; Volume 41 ,Issue : 3 ,pp : 204-208.
15- Hallock, Geoffrey G. MD., Utility of Both Muscle and Fascia Flaps in Severe Lower Extremity Trauma, Journal of trauma,injury,infection and critical care 2000; Volume 48(5), pp 913-917.
16- Godina M., Early microsurgical reconstruction of complex trauma of the extremities. Journal of Plastic and Reconstructive Surgery 1986; 78: 285-292.
17- R. Hertel S. M. Lambert, S. MüllerF. T.,et al, On the timing of soft-tissue reconstruction for open fractures of the lower leg ,Archives of orthopaedic and trauma 1999; VOL.119;NO.1-2.
18- Hoppenstal et al in Canale S.T.,Campbell's operative orthopaedics.(2003):10 ed.,Vol.3,St Louis.Mosby.51:2754-2756,55:3082-3087,56:3125-3141.
19- Al-Edany M.Sh, The treatment of open and closed fractures tibia by primary external fixation and bone graft. Thesis for Iraqi Board degree in fractures and orthopaedic surgery 2001, pp36-47.
20- Hoagland and States in Canale S.T.,Campbell's operative orthopaedics.(2003):10 ed.,Vol.3,St Louis.Mosby.51:2754-2756,55:3082-3087,56:3125-3141.
21- R.Hertel, M.D., Standard Regional Flaps for Soft-Tissue Coverage of the Leg. In: Techniques in Othopaedics; (2), Lippincott-Raven Publishers. Philadelphia 1995, 14:p122-123.
22- Adams C.I., keating J.F., Court-Brown C.M., Cigarette smoking and open tibial fracture. Journal of plastic and reconstructive Surgery 2001; 32:61-65.