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OPERATIVE MANAGEMENT, INFECTION ASPECTS & ROLE OF ANTIBIOTICS IN OPEN TIBIA FRACTURES

Orthopaedics

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ABSTRACT

Background and objectives: Since the advent of antibiotics in the 1930's and 1940's antibiotic resistance has been an issue. In the last decade, antibiotic resistance has become a major issue. Every orthopedic surgeon faces on a daily basis an increasing problem of antibiotic resistance in the effort to treat and prevent infections .In view of these above mentioned problems it becomes necessary to identify as early as possible all infections that occur ,determine their sensitivity and institution of appropriate antibiotics. The objectives of this study was to identify the common micro organisms that infect open tibial fractures in our hospital and determine the culture sensitivity patterns during the course of treatment in this hospital; To evaluate whether pre debridement and post debridement cultures are predictors of infection in open fracture wounds.

Methods: A prospective study was conducted in the Orthopaedics department of Tirtiary care Hospital, Surat where 27 cases of open tibial fractures were analysed to determine the infective organism and the culture sensitivity pattern of the isolated organism. A study was also conducted on wound bacterial cultures and their effectiveness in determining the prognostic value in deep wound infections.

Study design: All patients underwent clinical examination and history noted. Demographic details date and time of injury, mechanism of injury and time elapsed since injury to presentation in emergency department was noted. Wounds were swabbed before and after debridement and fractures were classified based on Gustilo Anderson's Grading system. Appropriate treatment for bony as well as soft tissue injury was carried out and patient was followed up in the ward to note the infections that developed from pre as well as post debridement cultures.

Results: Of the 27 pre and post debridement samples that were sent it was found that 41% of pre debridement samples were positive for infective organisms and of these 59% grew the infective organism in culture. In the post debridement series, only 20 % of the cultures grew the infective organism, of which only 64% cases got infected. Hence pre debridement cultures were more accurate in predicting open fractures infections. However of the cases that did become infected the infective organism was isolated in 85% cases. The most common organism that was isolated was found to be non fermenting gram negative bacillus followed by Pseudomonas in our study and the antibiotics recommended for treating these infections was found to be Cefeperazone sulbactum combination followed by Amikacin.

Conclusion: In summary, the use of pre and post debridement bacterial cultures has got a value in determining infections in open tibial fractures. The kind of organism will differ from hospital to hospital and culture sensitivity pattern will also vary. The most common organism that was encountered in my hospital was non fermenting gram negative bacillus followed by Pseudomonas; and the antibiotic of choice was found to be cefeperazone sulbactum combination followed by Amikacin.

KEYWORDS

open fractures; Infection; Tibia

INTRODUCTION

Since the advent of sulfonamides and penicillin in the 1930's and 1940's, specific antimicrobial resistance has been an issue. Penicillin resistant staphylococcus developed in the 1940's and 1950's. Methicillin resistance developed in the 1960s, and amino glycoside resistance among Pseudomonas Aeruginosa isolates was first seen in the late 1960's and 1970's. In the last decade, multidrug resistance has become frequent among nosocomial pathogens (that is staphylococcus, enterococcus and enterobacter species)*I*n addition antimicrobial resistance methicillin resistance among staphylococci, vancomycin resistance among enterococci and third generation cephalosporin and fluroquinolone resistance among pseudomonas, enterobacter and escherichia coli species) has become common in community acquired isolates.

Antimicrobial resistance is increasing for variety of reasons. These include sub optimal use of antimicrobial for prophylaxis and treatment of infection, prolonged hospitalization, increased number and duration of stay in intensive care units, multiple co morbidities in hospitalized patients. Increased use of invasive devices and catheters, ineffective infection control practices and non compliance with infection control practices .In general the level of antibiotic resistance is dependant on the proportion of resistant organisms introduced into the hospital from the community, the proportion that becomes resistant spontaneously or as a result of antibiotic use and the proportion that is spread from person to person .All these factors must be addressed in order to control the spread antimicrobial resistance organisms within the hospital.

OBJECTIVES

A. Identify the common micro organisms that are encountered in open tibial fractures and their antibiotic sensitivity patterns during the course of treatment.
B. To chalk out a treatment protocol that will guide all antibiotic regimes when planning initiation of antibiotics in open tibial fractures.
C. To evaluate whether pre debridement and post debridement samples are predictors of subsequent wound infections.

METHODOLOGY

This was a prospective study involving 27 patients who presented with open tibial fractures at Tirtiary care Hospital, Surat between January 2013 to December 2014.

Inclusion Criteria

All patients who have open tibial fractures of one or both limbs without other open long bone fractures, or open wounds of other parts of body or any other focus of infection detected clinically or laboratory wise.

Exclusion Criterion

Patient with open tibial fractures who have been treated by iv antibiotics or antibiotic dressings before coming to the emergency department Patient who have undergone wound debridement or surgical procedure for the fracture.

Study Design

All patients with open tibial fractures underwent a detailed history and clinical examination. From history patients who had received treatment elsewhere (as described in the exclusion criterion) were not included in study.

Patients whose profile fitted that of the inclusion criteria were considered in our study. As part of a working proforma the following details were noted from the patient and his at tenders-

- Demographic details (age sex) of the patient
- Date and time of injury

- The mechanism of injury
- Time elapsed since injury and presentation at emergency

All patients underwent trauma assessment and appropriate treatment in the emergency department, the affected limb(s) were splinted and the wounds were inspected for the size and extent of wound. Both soft tissue and bone status was assessed and the amount of contamination was noted.

All wounds were tentatively classified based on Gustilo Anderson classification of open fractures. All patients were given tetanus toxoid and the leg was splinted. The wound was covered by a sterile saline soaked gauge.

Under complete aseptic precautions the wound was first cleaned with sterile normal saline and then a wound swab was taken and sent to the microbiology department, This was the pre debridement sample. Then a thorough wound toileting was carried out in operation theatre using 6-10 liters of IV saline under complete asepsis .following which another swab was taken deep within the wound (post debridement cultures) the wound was then debrided under anesthesia and the open fracture is classified depending on the findings. The soft tissue wounds are addressed as the need may be and the bony injury is stabilized depending on factors like soft tissue coverage, contamination, communition and periosteal stripping. Further management of open tibial fractures is carried as per the guidelines given in literature, all patients are started on antibiotics after pre debrima culture samples were taken-cefazolin gentamycin and metronidazole for type 1, 2 and type 3 fractures were started on cephaperazone sulbactum and amikacin .all patient were given antibiotics for 3 days and subsequent antibiotics depended on the growth of those pre and post debridement cultures. If no growth occurred the antibiotics were stopped by 5th day. The patient during his hospital stay was assessed clinically for signs of infection and repeat cultures were sent; if infection was found to be present. The clinical parameters that were considered that suggested infection of wound were -

Local rise of temperature, tenderness, serosangunious discharge, frank pus abscess collection foul smell and necrosis of graft of flap Fever with chills The patient wound was inspected regularly and dressing using appropriate antibiotic was done If there was evidence of infection the wound was cultured and antibiotics started later to be followed by any secondary definitive soft tissue and bony procedure so as to obtain complete coverage of the open fracture wound. Once soft tissue cover was established and patient had no evidence of infection, the patient was then discharged from this hospital. The organisms that were encountered and there sensitivity was noted and later tabulated for analysis.

RESULTS

27 cases of open tibial fractures underwent treatment in orthopaedics department at Tirtiary care Hospital, Surat. Demographic data: Out of 27 patients, 23 were males and 4 were females.

The age of the patients ranged from 3 years to 75 years.

Table : Age group

Age Range	3 – 75 yrs
< 20 yrs	3
21 -40 yrs	18
41 - 60 yrs	4
>61 yrs	2

Etiology of open fractures:

There were various causes for open tibial fractures. However the most common was Road Traffic Accidents amounting to 79% of cases.

Table : Mode if injury

Mode of Injuries	No. of Cases
RTA	21
Fall	2
Industrial Accidents	4

Duration from injury to primary treatment: Of the 27 patients who presented in the emergency department 15 patients (55%) were taken up for debridement after 6 hrs of their injury and 12 patients(45%) were taken up for debridement within 6 hrs of injury.

Open fracture classification based on Gustilo Anderson's system:

Of the 27 open fractures that was encountered, the maximum number was type 2 which amounted to 9 cases and followed by type 3b which accounted for 7 cases.

Table: type of open fracture

Gustilo Anderson's Classification	
1	4
2	9
3a	3
3b	7
3c	4

From all 27 patients a pre debridement culture swab was taken and all patients underwent a wound debridement. Following wound debridement a post debridement culture swab was then taken.

For bony stabilization, the following fixation methods were used. some patients underwent more than one bony as well as soft tissue procedures.

Table : operative procedure

Bone stabilization procedures	
Exfix	13
Nail	9
Plate+screw	0
k-wire	0
Slab	1
Skeletal Traction	4

Table - Soft tissue procedures that were carried out following debridement

Soft tissue procedures	
primary wound closure	7
Flap	4
Amputation	1
SSG	2

Analysis of Pre debridement cultures:

A total of 27 wound debridement cultures were taken before wound debridement was carried out. Of these 11 cultures (41%) was found to be positive for organism and 16 cultures (59%) did not grow any organism.

Based on Gustilo Anderson's Classification the number of positive cultures was:

Positive pre debrima cultures based on GAC	
Gr 1	1
Gr 2	3
Gr 3a	1
Gr 3b	4
Gr 3c	2

Of the 27 cultures, 11 positive pre debridement cultures were obtained. Of these 4 were obtained in Grade 3b open tibial fractures and 3 were of Grade 2 open fractures.

Results of Pre debridement cultures:

Positive Pre debridement cultures: Of the 11 cultures that had grown organisms it was found that 6 cases were infected and 5 cases did not get infected Of these 5 infected cases 4 cases grew the infective organism whereas 1 case did not grow any organism.

Results of negative pre debridement cultures

Pre-debriment Negative cultures	
Noninfective fractures	15
Infective fractures	1

Of the negative pre debridement cultures, 15 cases did not cause infections whereas 1 case did get infected even though the predebridement culture did not register any growth.

Analysis of Post debridement cultures:
Total number of cases was 27.

Analysis of post debridement cultures	
positive	5
Negative	22

Post debridement positive cultures based on Gustilo and Anderson's classification Of the 5 case that were positive for infection in the post debridement samples the maximum cases were seen to be present in type 2 & 3 b open fractures and followed by type 3a open fractures.

Post debridement positive cultures	
1	0
2	2
3a	1
3b	2
3c	0

Positive Post Debridement Cultures

5 cultures were found to be positive, out of which 3 cases were clinically found to be infected as compared with 2 cases which did not have clinical infection.

Of these 3 infected cases, 2 cases did grow the organism in the infected fracture wound whereas 1 case was negative for the organism even though there was clinical evidence of infection.

Positive Post-debridement culture	
infected	3
non infected	2

Negative post debridement cultures -22 cases

Negative Post-debridement cultures	
Positive for organisms	3
Negative for organisms	19

Analysis of Infective Organisms in Open Tibial Fractures:

The following infective organisms were isolated in my study of open tibial fractures both on pre and post debridement cultures and subsequently.

infective organisms	
non fermenting gnb	9
Pseudomonas	8
Enterococcus	4
Enterobacter	3
Ecoli	3
MRSA	3
Klebsella	2
stap.aureus	2
citrobacter	1
proteus mirabalis	1

The most common organism isolated in this study was non fermenting gnb followed in decreasing frequency by pseudomonas, entrococcus enterobacter and Ecoli. Methicillin resistant staphalococcus (MRSA) followed by kleibseilla, staph.aureus citrobacter and proteus mirabilis .

Of the 27 cases that were analyzed, the total number of clinical infections was found to

6 cases. A categorization of the infective cases based on the type of fractures is enumerated below.

Sensitivity patterns of the organisms isolated:

In this study the following organisms were found to cause infection in open tibial fractures. The sensitivity patterns of these organisms will be enumerated in descending order of sensitivity to the antibiotic.

- **Non fermenting gram negative bacillus** -the sensitive antibiotics were Cefeperazone and sulbactum combination >Gentamycin/ Ciprofloxacin > Amikacin > Ceftazidime.
- **Pseudomonas** was found to be sensitive to Amikacin > Ceftazidime > Ciprofloxacin > Cefaperazone > gentamycin.
- **Enterococcus** was found to be sensitive to Gentamycin >Vancomycin > Pencillin
- **Enterobacter** was found to be sensitive to Amikacin > gentamycin >Ciprofloxacin > Ceftazidime/Cefotaxime.
- **E coli** was found to be sensitive to Amikacin >Gentamycin /Ciprofloxacin/Ceftazidime>Cefotaxime /Cefuroxime.
- **MRSA** was found to be sensitive to Vancomycin >chloramphenicol > Teicoplanin > Ciprofloxacin.
- **Kleibseilla** was found to be sensitive to Cefeperazone and sulbactum combination >Amikacin >Gentamycin, Zosyn and Netilimycin.
- **Staph aureus** was found to be sensitive to Cloxacillin / methicillin.

DISCUSSION

The problem of open fracture management has plagued surgeons since the time of Hippocrates. The open fractures represent a therapeutic challenge to the orthopaedics surgeons. They are difficult to treat and the cost of inadequate treatment is high both financial terms and in continuing patient disability .In the past open fractures of the tibia have been associated with infections, limb loss marked morbidity and high mortality rates owing to sepsis.

Prevention of wound sepsis remains the prime objective in the management of open tibial fractures. The reported infection rates in these fractures have ranged from 3% to25% in literature[46.]

There is universal agreement that open fractures require emergency treatment in the form of wound debridement and irrigation .Beyond this, use of cultures in the assessment and predictivity of infections is still controversial. It is universally accepted that antibiotics have an important role to play in the treatment of open tibial fractures but the duration and initiation of treatment still remain open to debate.

This study was undertaken in Tirtiary care Hospital, Surat to analyze the type of organism that most commonly infect our open tibial fractures and the sensitivity pattern that they develop in our hospital setting. This would be used to plan a treatment protocol to direct the use of antibiotics din the management of these infections in our hospital.

27 cases were included in this study .Males were found to more affected than females and amounted to 88% of the cases seen.

Most patient were in the age range of 21 to 40 years (66%). Road traffic accidents caused the maximum number of cases (79%). 55% of cases presented in the emergency after 6 hours of injury and were taken up for wound debridement as compared to 45% of cases who presented in the emergency within 6 hours of injury. On correlation with the number of infections that developed in open tibial fractures it was found that 65% of these patients got infected as compared with 355% of cases which did not develop infection.

When these cases where classified based on Gustilo Anderson s classification it was found that 31% cases were of the type 2 and followed by the 25% of cases which was type 3b.

On comparison between pre and post debridement cultures and there association with fracture classification of Gustilo and Anderson' it was found that type 3b were the most commonly affected (36%) followed by 32% infection in type 2 fractures.

Numerous studies support the fact that the incidence of infection in open fractures correlates directly with the amount of soft tissue, bony injury and fracture classification[12, 29, 41]

The reported infection rate for open tibial fractures was found to range from 0 to2% in grade 1, for Grade 2 it was 2%to 7% and for grade 3 it was found to be 10% to 25%.

Literature also reports infection rate for sub classification of grade 3 fractures .It was found that 3a infection rates were 7%, 3b fractures had infection rates ranging from 10% to 50% and for 3c fractures the infection rates were 255 to 50%.[11,12,42,43,41.]

The results of my study corroborates with these findings.

On analysis of pre debridement cultures samples it was found that in 41% of the total cases were able to pick up an organism on culture as compared to 20% of post debridement samples to grow an organisms .In summary the pre debridement samples was better predictors culture positive infection in open tibial fractures as compared to post debridement samples.

However of the positive culture in pre debrima samples, only 59% of these cases were able to cause infection in open tibial fractures as compared to 64% of positive post debrima samples .This indicates that post debrima samples were better indicator clinical infection in open tibial fractures.

On analysis of infected wounds which had grown pre and post debridement cultures positive it was found that post debrima cultures, the organism was isolated in 93% cases as compared with pre debrima cultures where 85% cases the organism was isolated..

On analysis of these variables by the Chi square test the p value was found to be less than and the variables were significantly associated

In summary it was found that pre and post debrima in this study was found to be good indicator as well as predictors of infection in open tibial fractures.

On comparison with a study conducted by Jackson Lee (b)

Pre debridement

	Positive	Negative	Non infected	Infected	Organism+	Organism –
Our Study	41%	59%	41%	59%	85%	15%
Comparative study	53%	47%	80%	20%	29%	71%(b)

It was found that the pre debridement infected cultures and positively for infective organism in my study was found to be significant when compared to a study done by Jackson Lee.

Post debridement

	Positive	Negative	Infected	Non infected	Organism+	Organism –
Our Study	20%	80%	36%	34%	93%	7%
Comparative study	27%	73%	28%	72%	89%	11%(b)

In the post debridement culture study it was found that there was a better correlation of my findings with Jackson study with respect to the isolation of organism from infected wound.

Patzakis in his study in 1974 showed that approximately 35% of initial cultures of open fractures produced no bacterial growth. However if a positive culture was obtained it would be the organism most likely to be associated with the infection. Some patients developed infection even though the culture was negative but these rates were much lower.[45]

According to Gustilo and Anderson in their series 70.3% of open wounds yielded positive results .Therefore they consider the routine use of antibiotics in open fractures as therapeutic rather than prophylactic and an subsequent change should be guided by the sensitivity of the organism isolated.[12]

According to Jackson lee ,in conclusion he feels that both post and pre debridement samples have essential no value and is an unnecessary expense to the patient and hence should not be used. I however beg to differ, this study does show a statistically significant correlation between pre and post debridement cultures and the presence of infection when it does develop and sometimes it may provide the basis for initiating antibiotic therapy early ,even when initial cultures are negative but clinical evidence of infection is present . On analysis of the infective pattern that we encountered in our study the most common organism was gram negative bacillus which was the most commonly occurring organism in open tibial fracture wounds. This was followed by Pseudomonas and enterobacter came next.

Gustilo and Anderson in their study of open fractures found that the most common organism that was encountered in open tibial fractures was Staphylococcus aureus.[12] Other organisms encountered were Klebseilla, enterobacter, E Coli, proteus and coagulase negative staphylococcus.
In another study by Patzakis and co workers it was found that the most common infecting organism was Staphylococcus Aureus and followed by mixed gram positive bacillus which included coagulase positive staphalococcus.[44]

Gram negative bacillus was the most common organism isolated in my study, It was found to be sensitive to Cefeperazone and sulbactum combination in most of the cases. Gentamycin and Ciprofloxacin also were found to be sensitive against the organism.

Literature advocates the use of 2nd or 3rd generation Cephalosporin depredating on the contamination and the type of fracture classification and the addition of an amino glycoside in grade 3 fractures as these fractures were found to have a 10 to 20 times higher infection rates as compared with type 1and 2 open fractures.[11,33,37.]

Based on our study we would like to suggest the following;

All patients with open fractures will need to be assessed individually and the basic principles of open fracture management must be carried out including wound debridement, fracture stabilization and soft tissue cover where appropriate and depending on local factors of the wound, Antibiotics should be instituted in the emergency and continued in the ward till the cultures are available and further treatment will be governed by it. Broad spectrum antibiotics can be used initially but subsequent culture growth should govern the antibiotic protocol which will vary from hospital.

In oury hospital we would recommend the use of Cefazolin, gentamycin and metronidazole for all grade 1 and 2 fractures and for type 3 and its subtypes I would recommend cefeperazone and sulbactum combination with Amikacin and the use ofmetronidazole if there is evidence of anaerobic contamination.

CONCLUSION

Gram negative bacillus was the most frequently isolated organism in the cultures of open tibial fractures .This was found to cause a significant number of infection in open tibial fractures .Type 3b was the maximum number of open fractures that were infected and those patients that presented in the emergency greater than 6hrs had an increased infection rate when compared to those who reached the emergency within 6 hours.
The organism was found to be sensitive to cefeperazone sulbactum combination followed by Amikacin and then to ciprofloxacin.
Pre debridement as well as post debridement cultures have got a role in detecting infections in open fractures and their association in predicting infection is notable.

REFERENCES

1. Andrew R Burgress, Atilla Poka, RJ Brumback. Management of open grade 3 Tibial fractures. Orthopaedics clinics of North America Vol 18; No 1: Pg 85-92.
2. Riska LB, Von Bonsdoff H, Hakkenein S Primary operative fixation of long bones in patients with multiple injuries. J Trauma 1977; 17: Pg 111-121
3. Alexander RH, Procter JH, Advanced trauma Life Support (ATLS) program for Physicians 5th edition Chicago, American college of surgeons. 1993
4. Robert J Claude, Peter J Stern. Severe open fractures of the tibia J Bone and joint surgery Am 1987 69; 6:
5. Olson SA. Open fractures of the tibial shaft -Current treatment instructional course lecture 1997 ;46; Pg 293-302.
6. Olson SA. Open fractures of the tibial shaft Journal of bone and joint surgery Am 1996; 78: pg 1428-1436
7. Kaysinger KK, Nicholson NC, Ramp Wk. Toxic effects of wound irrigation solutions on cultured tibial osteoblasts. J Ortho Trauma 1995,9 Pg 303-311
8. Jackson Lee. Efficacy of cultures in management of open fractures Clin Orthop 1997; 339: Pg 71-75
9. Clifford H, Turren, Anthony JD. Treatment of grade 3B and grade 3C open tibial fractures Orthopaedic clinics of north America Vol 25; No 4: pg 561-569
10. Rosenthan BD Wilson FC Funderburk CH The use of bactiricin irrigation to prevent in post op skeletal wounds Journal of bone and joint surgery (Am) 71;427;1989
11. Brumback RJ, Ellison PS, Poka A. Intramedullary nailing of open fractures of femoral shaft J Bone and Joint Surg Am 1989; 71: Pg 1324-1331
12. Gustilo RB, Mendoza RM, Williams DN. Problems in management in severe type 3 open fractures. J Trauma 24; 8 : Pg 742-746
13. Gustilo RB and Anderson JT Prevention of infections in the treatment of 1025 openl o n g bone fractures. J Bone joint surgery Am 1976; 58: Pg 453-456
14. Modrall JG. Vascular considerations in extremity trauma. Orthopaedic clinics of North America 24;3: Pg 557-564
15. Rose SC Moore EE .Trauma angiography use of clinical findings to improve patient selection J Trauma 18: 240 1985
16. Bishara RA, Pasch AR, Improved results in the treatment of civilian vascular injury associated with fracture and dislocation. J Vasc Surg 3;1986: Pg 707-711.
17. Rockwood and Green Volume 1; 5th edition pages
18. Gustilo RB. Current concepts in the management in open fractures. Instructional course lectures 1987; 36:Pg 359-366
19. Anglen J. The efficacy of various irrigation solutions in removing slime producing staphalococcus. J Ortho trauma 1997; 8: Pg 390-396
20. Dirschl DR,Duff GP, Dahners LE. High pressure pulsatile lavage irrigation of intra articular fractures, effects on fracture healing. J Ortho Trauma 1998;12:Pg 460-463
21. Edin MI, Miclau T, Lester GE. Effect of Cefazolin and Vancomycin on osteoblast in vitro. Clin Orthop 1996; 333: Pg 245-251
22. Tsherne H. The management of open fractures in fractures with soft tissue injuries New York Sprenger Verlag 1984
23. Scully RE,,Artz CP, Sako Y. An evaluation of surgeons criterion for determining the viability of muscle during debridement Arch Surg 1956; 73 1031-1035
24. Swiontkowski MF. Criterion for bone debridement for massive lower limb trauma Clin Orthop ;1989 243 pg 41-47
25. Wagner WH, Yellin AE Weaver FA. Acute treatment of penetrating popliteal art trauma

Annals of vascular surgery 1994;8: pg 557-565
26. Cooney WP 3, Fitzgerald RH, Dobyns JH. Quantitative wound culture in upper extremity trauma. J Trauma 1982;22 :Pg 112-117
27. Robson MC, Duke WF. Rapid bacterial screening in the treatment of wounds J Surg Res 1973;14
28. Lange RH, Bach AW. Open tibial fractures with associated vascular injury ; prognosis for limb salvage.J Trauma 1985 ;25: Pg 203-208
29. Patzakis MJ. Use of antibiotics in open tibial fractures Clin Orthop 1983; 178: Pg 31-34
30. Patzakis MJ and Wilkins Factors influencing infection rate in open tibial fractures. Clin Orthop 1989; 243: Pg 36-40
31. Ramesh KS, NRS Murthy, Shivinder S Gill, Onkar S Nagi. Bacterial load in tissues and its predictive value for infection in open fracture. Journal of Orthopaedic Surgery 2000 82; 2: Pg 1-5
32. Ostermann PA, Henry SL. The role of local antibiotic therapy in the management of compound fractures Clin Orthop 1993; 95: Pg 102-111
33. Thomas J Moore, Charles Mauney and Jerry Baron. Use of Quantitative bacterial counts in open fractures. Clinical orthopaedics and related research No 248; Nov 1989
34. Eckmann JB Jr, Henry SL. Wound and serum levels of tobramycin with prophylactic use of tobramycin impregnated beads. Clin Orthop 1988;237: Pg 213- 215
35. Jeanette Wilkins and Michael Patzakis. Choice and duration of antibiotics in open fractures. Orthopaedic Clinics of North America 1991 22; 3: Pg 433-436
36. Gustilo RB, Merkow RL, David Templeton. Current concepts review management of open fractures. J Bone Joint Surgery Am 1990 72; 2: Pg 299-303
37. Lawrence RM , Hoeprich PD, Huston AC. Quantitative microbiology of traumatic orthopaedics wounds J Clin Microbiology1987; 8:Pg 673
38. Van Winkle BA, Neustein J. The management of open fractures with sterilisation of large, contaminated, extruded cortical fragments. Clin Orthop 1987; 223: pg 275-281.
39. Kaiser AB Antimicrobial prophylaxis in surgery. N England J of med 315;129: 1986
40. Dellinger EP, Caplan ES, Weaver LD. Duration of preventive antibiotics administration for open fracture of extremity. Arch Surg 123; 333:1988
41. Gustilo RB, Gruninger RP. Classification of type 3 open tibial fractures relative to treatment and results. Orthopaedics 1987 ;10 :Pg 1781 1987
42. GJ Clancy, ST Hansen. Open fractures of the tibia - a review of 102 cases. J Bone Joint Surgery Am 1978;60:Pg 118-122
43. Benjamin JB, Efficacy of topical antibiotic irrigant in decreasing or eliminating bacterial contamination in surgical wounds. Clin Orthop. 184; April 1984: Pg 114-117.
44. W W Rittmanns, M Schibili P Matter Open fractures -long term results in 200 long cases Clin Orthop1979;138: Pg 132-140
45. Miclau T, Edin ML, Lester GE. Bone toxicity of locally applied aminoglycoside. J Ortho trauma 1995; 9:Pg 401-406.