The Bone & Joint Journal

Journal club: 24 February 2014

Organisers: Neil Wickham and Aisha Raizak

Attendees: Mr Jason Bernard Consultant and Chair; Mr Sebastien Dawson-Bowling, Consultant and Chair; Miss Aisha Raizik, ST3+ SpR; Mr Dimos Evangelidis, ST3+ SpR; Mr Neil Wickham, CT2; Mr Ollie Boughton, ST2; Miss Gemma Green, Junior Trauma Fellow.
Department of Trauma and Orthopaedics, St George's Hospital, London

Theme: Management of open long bone fractures

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;58:453-458.

Reviewer: Mr Neil Wickham

Aims and objectives

- Best strategy for closure of wound; primary vs secondary wound closure +/- skin grafting or local flap
- Best strategy for fixation: External vs Internal fixation, types of internal fixation
- Role of antibiotics in open fractures

Design

1) Retrospective cohort study of 673 open long bone fractures (1955 – 1968)
2) Prospective cohort study 352 open fractures (1969 – 1973)

Retrospective cohort protocol for all open fractures:

- Adequate debridement and copious irrigation of the wound
- Primary closure whenever possible, regardless of the severity of the fracture and the soft-tissue injury (as of 1966)
- Internal fixation used at the discretion of surgeon and not in accordance with any rigid criteria.
- Routine antibiotics (dose and regime changed x3)

Retrospective cohort inclusion / exclusion criteria:

Consecutive open long bone fractures (humerus, radius and ulnar, femur, tibia and fibula)

Retrospective cohort outcomes:

- Infection rate all fractures
- Infection rate in tibia and fibula fractures treated with primary internal fixation vs no primary internal fixation
- Infection rate in primary vs secondary wound closures

Retrospective cohort results:

- N = 673 open long bone fractures
- Infection rate: 1955-1960 = 11.85% 1961-1968 = 5.24%
- Primary internal fixation infection rate = 19% vs no primary internal fixation infection rate = 5%
- Primary closure infection rate 6%, secondary closure 20%. However with extensive soft tissue injury (amputation, segmental tibia, extensive laceration) infection rate was much higher (44%) if these were closed primarily

Prospective cohort protocol:

Fractures were sub classified as follows:

Type I: An open fracture with a wound <1cm long and clean.
Type II: An open fracture with a laceration >1cm long without extensive soft-tissue damage, flaps, or avulsions.
Type III: Either an open segmental fracture, an open fracture with extensive soft-tissue damage or a traumatic amputation. Special categories in Type III were gunshot injuries, any open fracture caused by a farm in jury, and any open fracture with accompanying vascular injury requiring repair.

- All open fractures were treated as emergencies
- Cultures were obtained routinely on admission and before wound closure or application of the postoperative dressing after 1971
- Antibiotics given on admission and for 3 days post operatively or continued if wound left open
- Thorough debridement and copious irrigation were emphasized, and for the more recently treated Type III injuries jet lavage was used
- No primary internal fixation was employed except in rare cases in which vascular injury required repair. External skeletal fixation or traction was the preferred method of immobilization
- Primary closure was performed in Type I and II fractures and delayed closure, in Type III lesions

Prospective cohort inclusion / exclusion criteria:

Consecutive open long bone (humerus, radius and ulnar, femur, tibia and fibula) fractures

Prospective cohort outcomes:

- Infection rate all fractures
- Contamination of wounds and sensitivity of organisms
- Union rate

Prospective cohort results:

N=352 (Type I = 78, Type II = 181, Type III = 67, 26 lost to follow up)

- Overall infection rate (all fractures) 2.4% ($p < 0.02$)

- 80% wound cultures positive on admission - nearly always sensitive to Cephalosporins
- Uneventful union rate of fracture 86.4% (197 of 352 followed up)

Author conclusions

- Open fractures require emergency treatment including adequate debridement and copious irrigation
- Primary closure is indicated for Type I and II open fractures but delayed primary closure including split thickness skin grafts or appropriate flaps should be used for Type III open fractures
- Internal fixation should be avoided – external fixation preferred
- Open fractures associated with arterial injury should be treated with skeletal traction rather than internal fixation
- Antibiotics before, during and after surgery with Cephalosporin the preferred class

Critique

This landmark paper created the basis for the most commonly used classification system for open fractures of the tibia. It contained a large number of patients with a straightforward statistical analysis. It also included lost to follow up data and covered many areas of open fracture care within a single paper.

Unfortunately the aims and objectives of the paper are not explicitly stated. It also contains a slightly unconventional study design from a single centre. However the nature of these injuries mean they are not likely to be suitable for randomised control trials. In this study multiple variables are also manipulated between the groups meaning that the contribution of each individual treatment strategy is lost. The techniques described are also somewhat outdated compared with modern soft tissue coverage and bone fixation techniques. Despite these limitations this paper remains highly influential on the management of open tibial fractures.

Gopal S, Majumder S, Batchelor AG, Knight SL, De Boer P, Smith RM. Fix and Flap: the radical orthopaedic and plastic treatment of severe open fractures of the tibia. *J Bone Joint Surg [Br]* 2000;82-B:959-66

Reviewer: Mr Oliver Boughton

Aims and Objectives:

- Importance of early soft tissue cover in open tibia fractures
- Role of immediate internal fixation considered in open tibia fractures
- Emphasise combined orthopaedic and plastics service

Design

- Single centre, retrospective review of notes (case series) in Leeds, UK
- 84 consecutive patients' notes reviewed between 1990-1998
- Gustilo-Anderson Grade IIIb or IIIc open fractures of tibia after blunt trauma treated with a radical protocol of early soft tissue cover
- Patients assessed whether deviated from "ideal management"; radical debridement, skeletal stabilisation as per fracture type and early soft-tissue cover with vascularised muscle flap

- All patients followed to end of clinical course (union, amputation or death) for minimum one year

Data included in analysis:

- Grading of fracture
- AO Classification
- Fixation type
- Flap type and timing

Outcomes:

- Secondary procedures
- Time to union
- Superficial/deep infections

No statistical significance calculations in methods/results

Results:

- 84 patients originally (3 left region, one died from unrelated causes)
- 80 patients and 84 fractures analysed (67 men,13 women, mean age 37 years)

All grade IIIc injuries had immediate revascularisation and went on to union

4 amputations (one failed flap, one farmyard injury, 2 late)

Secondary procedures:

- Internal fixation:
  4 amputations (2 nails, 2 ORIF). 59 fractures united
  19/59 (33%) required further procedures to achieve union

- External fixation:
  19 patients with fractures that united
  8/19 (42%) required further procedures to achieve union

Table 1: Summary of outcomes from soft tissue coverage timing:

			Time to union (weeks)			
Timing of cover	**Number**	**Amputations**	**Internal fixation**	**External fixation**	**Skin infection**	**Deep infection**
Immediate (<24hrs)	33	0	28	44	2 (6%)	1 (3%)
Early (<72hrs)	30	2	36	60	4 (13%)	3 (10%)
Late (>72hrs)	21	2	31	56	7 (33%)	6 (30%)

Author conclusions:

- Aggressive management of severe open tibia fractures effective
- Delay is not necessary if healthy soft tissue can be imported reliably into injury zone
- Internal fixation should be considered (they treat as if a closed fracture)
- Problems with soft tissue reconstruction with ex-fix pin site infection

Recommendations for practice:

- Treat in specialist centre with joint orthopaedic and plastics service. Initial debridement must be thorough
- Early soft tissue cover
- Select best implant for bony injury

Critique:
The article is presented in a straightforward way and the topic covered both timely and relevant. It includes a thorough and up to date literature review and is likely to stimulate further research and learning on this topic. The implications for practice are also discussed.

Unfortunately the aims and objectives of the study are not explicitly stated and whilst the article itself is well structured the abstract is less so. The limitations of the study and recommendations for further research are also not explicitly discussed by the authors. Despite these limitations the article does contain enough evidence to change practice particularly with regard to soft tissue coverage but less so with choice of fixation.

Giannoudis PV, Papakostidis C, Roberts C. A review of the management of open Fractures of the tibia and femur. *J Bone Joint Surg [Br]* 2006;88-B:281-9.

Reviewer: Mr Dimos Evangelidis

Aims and objectives:

- Review article
- Systematic analysis of publications in English literature during the last two decades regarding treatment of open fractures of the tibia and femur focusing specifically on the outcome and complications

Design:
Inclusion criteria:

- Patients suffering from an open fracture of the tibial or femur diaphysis (solitary or polytrauma)
- Stabilisation by Exfix, IM nail (with or without reaming), plates & screws
- Complete data regarding union (the primary outcome), rates of deep infection and re-operation
- The study described more than eight cases

Articles excluded: Open metaphyseal tibial fractures, open intra-articular fractures and floating-knee injuries.

In total 30 studies were analysed

Statistical anaylsis: SPSS 12.O, ANOVA and a post-hoc Tukey test ($P<0.05$)

Results:

1) Open tibial fractures: management of skeletal injury

Table 1: Open tibial fractures – fixation types and outcomes:

Fixation	Union (%)	Delayed union (%)	Malunion (%)	Further operation (%)	Deep Infection (%)	Bone graft rate (%)
Exfix	94	24	20	68.5	16.2	46.2
Unreamed tibial nail	95	22	10	33	7	14.4
Reamed tibial nail	97	N/A	6	31.6	6.4	15.5
ExFix then delayed reamed tibial nail	93	14	11	23	17	17
Open Reduction internal fixation	100	38	4	69	35	42

Exfix *vs* unreamed IM nails

Meta-analysis of randomised prospective studies. Four studies, 296 fractures

- No statistically significant difference in: union, delayed union, deep infection and chronic osteomyelitis
- ExFix: increased rate of: malunion, further surgery and autologous bone graft
- Unreamed IM nailing increased rate of implant failure

" Even in grade-IIIB open tibial fractures, unreamed nailing did not seem to alter the relative risk of nonunion or deep infection "

Reamed vs unreamed nails

One prospective, randomised trial, 94 fractures.

- No statistically significant difference; time to union, rate of union, infection, nail breakage (unreamed = more broken screws) and functional outcome

Reamed nails vs Exfix

One article – indirect comparison

- Use of reamed nails significantly reduced the risk of re-operation
- Equal risk of deep infection and non-union

Exfix vs ORIF

One prospective, randomised study, 56 patients.

- Plates & screws higher % of; delayed union, higher rate of re-operation and tendency for lower malunion rate

2) Open tibial fractures: Management of associated soft-tissue injury

All Grade IIIB / IIIC injuries

Early wound cover (<8 days) vs Later cover (8 to 30 days)

- Early wound cover (<8 days): Less wound complications, lower infection rate, lower malunion and non-union rate

'Immediate' or 'very early fix and flap' protocol

- Drawbacks; Need for plastic surgeons, major microsurgical procedures are contraindicated in polytrauma and hypovolaemic shock
- Favourable results due to the immediate reestablishment of a physiological wound barrier

- In less severe grades (I to IIIA) a secondary wound closure seems to yield the best results

3) Open tibial fractures and compartment syndromes

Blick et al (1986):

- 198 open tibial fractures, 83% of the fractures grade III, 94% of the fractures moderately to highly comminuted. Overall incidence 9.1%
- A closed-head injury, the need for intubation and prolonged anaesthesia can mask its clinical manifestation.
- Monitoring of the intercompartmental pressures in all unconscious and uncooperative patients suffering from a high-energy tibial fracture with a concomitant tense and swollen calf is mandatory

4) Open fractures of the femoral shaft

Reamed IM nailing vs Exfix
Ten papers (one randomised, prospective trial), 525 open fractures.
Similar outcome with reamed IM nail as for closed fractures nailed

Table 2: Open fractures of femoral shaft (Reamed IM nail vs Exfix)

Outcome	**Reamed IM nail**	**Exfix**
Union (%)	98	100
Delayed Union (%)	1.9	0
Malunion (%)	6.5	23.3
Infection (%)	3.3	13.3
Re-operation (%)	13.5	17
Bone graft (%)	3	10

Primary Exfix then conversion to IM nail is useful for interim fixation particularly in polytrauma, stabilisation in group-IIIC injuries and patients with associated unstable pelvic or spinal injuries that are not suitable for traction table.

Reamed vs Unreamed femoral nails
Three papers 324 open femoral fractures
Concerns expressed regarding biological consequences of reaming; increased risk of pulmonary complications or infection.

- Mean time to union significantly shorter in 2/3 papers for reamed nails (P=0.007 and P=0.009)

Critique
This review article is highly ambitious in scope covering a range of topics for open fractures of the lower limb. It is published in a high impact journal and is a multi-centre review. The inclusion and exclusion criteria are both clearly stated and reasonable for the research question. A large number of studies have been included in the review.

The main weakness of this review is the number of separate research questions looked at. This prevents more detailed review and evaluation of the studies included. There is also no formal conclusion or recommendations at the end of the paper, instead some of the

questions have conclusions and recommendations for practice at the end of the short section on that specific question. However the review is certainly of sufficient quality to influence changes in practice for the wider audience and makes an important contribution to the subject of management of open fractures of the lower limb.

Helfet DL, Howey T, Sanders R, Johansen R. Limb salvage versus amputation preliminary results of the mangled extremity severity score. *Clin Orthop Relat Res* 1990;256:80-6.

Reviewer: Miss Gemma Green

Aims and Objectives

- Can an *objective* score of severity help surgeons to decide which patients would be best served with primary amputation over limb salvage
- To provide an objective scoring system to assess the mangled lower limb

Design

2 part study: retrospective and prospective

1) Retrospective study

25 patient notes reviewed, lower limb only. 4 domains identified based on previous literature review:

- Skeletal/ soft tissue ijury: (Low, Medium, High energy or Massive crush)
- Shock: (None, transient and prolonged hypotension)
- Ischaemia (none, mild, moderate, or advanced)
- Age: (<30y, 30-50y or >50y)

2) Prospective study

- 2 facilities, 26 patients
- Inclusion: Type IIIc tibial open fractures
- Patients scored but score not taken account into decision making
- Correlated scores with outcomes

Results

In both the retrospective and prospective groups the mean scores of amputated vs salvaged limbs were significantly higher

Author conclusions

- Futile salvage attempts can increase both psychological and physical harm in addition to increasing costs.
- An objective score may help identify patients who do better with salvage vs amputation.
- Aids in explanation to patients and difficult decision making process

Critique

The article is written by a highly published author and published in high impact factor journal. It has a clear hypothesis and aim and tackles an interesting and relevant topic. It also contains both a retrospective and prospective arm in an attempt to validate the score.

The small sample size used in both retrospective and prospective arms is a major weakness of the study. Additionally the score does not take into account many individual patient

characteristics that may affect outcome. It also does not take into account multidisciplinary input. It is unlikely that in its current form the score would inform a decision to amputate or salvage a limb however with further refinement and validation it maybe a useful tool.