The Management of Posttraumatic Bony Wounds - a Thirty Year Experience

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My interest in the approach and management of posttraumatic long bone infections began during my tenure as the Chief Orthopaedic Resident of the West Service in 1979. Confronted with an elderly woman with an infected nonunion of her femur following open reduction and plate fixation, I sought advice from numerous senior attending staff only to realize that no treatment protocols existed and that an air of pessissm abounded as I was confronted with the current opinion that one could not "cure" this problem.

I did what I thought best which consisted of repeated debridements, external fixation, and ultimately a cancellous autogenous iliac crest bone graft which to my surprise controlled the sepsis, maintained her limb length , and healed the femur. She remained infection free until she passed away 15 years later—and thus began a lifetime interest and experience with over 400 such patients.

Rather than define these problems as "osteomyelitis", we preferred to call these "posttraumatic bony wounds" as the problem was not really the growth of bacteria as it is in osteomyelitis, but rather the wound conditions that support bacterial growth. Working closely with my plastic surgery colleagues and interested members of the infectious disease department, a treatment protocol was established based upon extensive bony debridement; external skeletal fixation maintaining limb length, alignment, and joint mobility; free tissue transfer where indicated—then followed by culture specific parenteral antibiotics after wound closure. It is surprising to me now when I think back to the early 1980's when I was admonished for applying external fixation in the face of active long bone infections! (8). It became evident rather quickly that the significance of the flap coverage was that it permitted an appropriate and extensive bony debridement as well as providing a well vascularized environment (3,6,9,13,14,34). Even the well established need for a minimum of 6 weeks of parenteral antibiotics came into question. Led by Dr A. W. Karchmer of the infectious disease service and along with Drs May and Gallico of the plastic surgery division, we established a prospective study randomizing patients to 6 weeks vs 1 week of culture specific antibiotics starting at

Fig 1a

Fig 1b

Fig 1c

Fig 1a-c A chronic infection following ankle arthrodesis
A) the chronic Type I bony wound
B) s/p extensive debridement in preparation for free groin flap by Dr James May
C) 13 year follow-up

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Fig 2a

Fig 2b

Fig 2c

Fig 2 a-c A chronic infection in a 40 yr old male s/p over 15 debridements and multiple courses of parenteral antibiotics

a) the appearance of the limb with chronic infection and stasis changes

b) xray following extensive debridement reflecting a Type II limb which needs bone graft for support

c) 10 yr s/p free lattisimus flap by Dr Greg Gallico and cancellous graft under flap

the time of wound closure. A total of 44 patients were studied with only 1 recurrence in each cohort (14)

A classification was established to define the very different clinical presentations Type I defined an intact bone with only superficial cortical involvement. Type IIA involved both cortical and endosteal bone but stable post debridement. Type IIB was both infected cortical and endosteal bone but unstable post debridement and lastly Type III reflecting segmental bone loss or nonunion. Further experience particularly with infected tibial fractures led to a decision making algorithm based upon a combined experience of 4 investigators as to how long it might be for a patient once treatment initiated to ambulate without additional support. The classification applies only after completion of the debridements (35):

Type I: Tibia intact not requiring bone grafting (Fig.1)

Type II: Tibia intact but bone graft needed for structural support (Fig.2)

Fig 3a

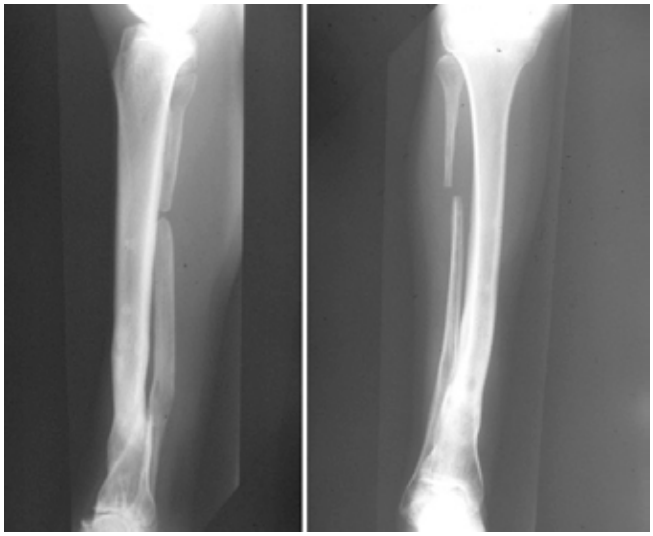


Fig 3b

Fig 3c

Fig 3a-c An infected, deformed limb in a 38 year old woman

a) the limb upon presentation/ post debridement and external fixation/ and post lattisimus flap with skin graft by Dr James May

b) s/p union with cancellous graft placed under the flap

c) donor site of the flap and clinical appearance of the limb

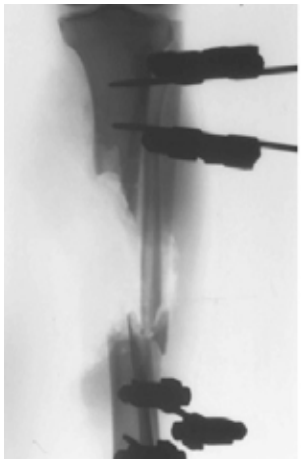
Type III: Tibial defect less than 6 cm with an intact fibula (Fig.3)

Type IV: Tibial defect greater than 6 cm with an intact fibula (Fig.4)

Type V: Tibial defect greater than 6 cm without an ipsilateral fibula (Fig 5)

Fig 4a

Fig 4c



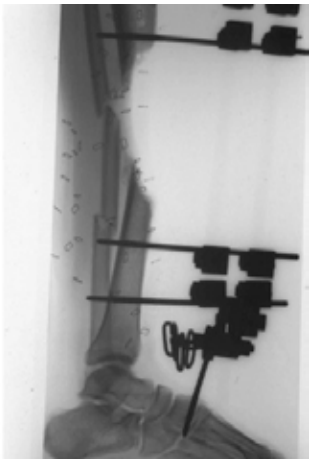


Fig 4b

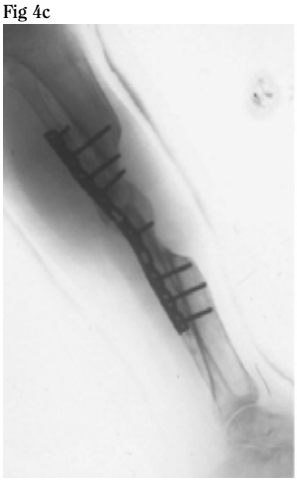


Fig 4d

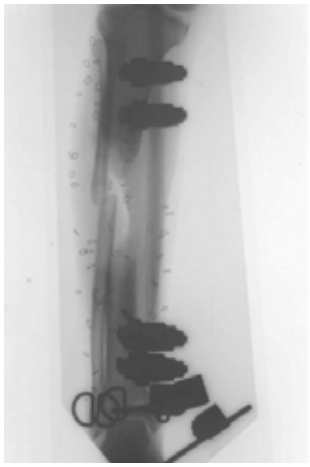


Fig 4c

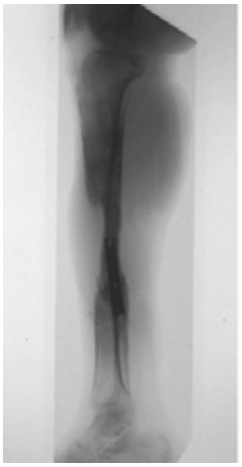


Fig 4d

In 1995 we published a study of 36 patients treated for an infected nonunion of the tibia with an average follow-up of 61 months (range 24-133 months.) (18) Twenty patients were male and 16 female with one patient having bilateral involvement. Seven involved the proximal third, 11 middle third, and 19 distal third. The average duration of infection was 15 months with 34 limbs actively draining upon presentation. Multiple organisms were cultured in 23, gram positive in 10, and a gram negative bacteria only in one limb . Thirty were Type III, 4 Type IV, and 3 Type V. Union was achieved in 35/37 patients with resolution of signs and symptoms of infection

Fig 4e

Fig 4 a-e Bilateral infected nonunions in a laborer s/p surgery for open fractures

a) extensive soft tissue and bony wounds with Type IV bone loss but useable fibula

b) s/p radical debridement and external fixation of the left leg

c) s/p plate fixation of the fibula and posterlateral bone graft

d) s/p free flap and posterolateral graft and plate of the fibula in the right leg

e) one year post surgery with functional gait and equal leg lengths

Fig 5 A chronic bony wound with septic bone over one-half of the tibia and a fibula not useable (Type V) and follow-up xray after a vascularized fibula graft.

also in 35 patients. One patient had persistent drainage and one had a positive culture when a traumatic refracture was treated with internal fixation.

As I became more involved in the treatment of these patients, it became very apparent that the impact of their disorder extended far beyond their lower limb. Utilizing the Nottingham Health Profile as well as a personal essay, the subjective Health Outcome evaluation identified ongoing pain in 65%, low energy in 61%, decreased mobility in 40%, and social isolation in 31%. The patients' personal essay revealed an ongoing financial impact in 50% and psychological impact in over 30%.

This outcome evaluation supported the impression that an infected nonunion of the tibia should be treated aggressively from the onset and avoid long and repeated hospitalizations if possible.

What also proved to be both surgically challenging and rewarding was the opportunity to use a variety of techniques to reconstruct residual bony defects. These included anterior cancellous autogenous iliac crest graft under a free flap in 14 patients (Fig.2); open cancellous grafting in 7 (Fig.6); postero-lateral cancellous graft in 2 (Fig 4); a vascularized fibular graft in 2 (Fig 5); and a fibula-pro-tibia in 2 (Fig 7). In addition we had the opportunity to use the Ilizarov method in a number of other patients. (13,18,19,20,22,26,37)(Fig. 8) The indications, advantages, and disadvantages are identified in Tables 1-4. When evaluated at the final follow-up, 27 limbs lengths were within 1 cm of the opposite side; 31 limbs with less than 5 degrees of angular or rotational deformity; and the knee motion 91% and ankle motion 71% of the opposite limb.

The reconstruction of these chronic bony wounds also opened up varied opportunities for microvascular soft tissue and bony reconstructions. Over the three decades of this experience, at least 50 vascularized fibular reconstructions were performed both in the upper and lower limb. The vascularized bone graft proved capable of bridging massive segmental bony defects with the capacity to hypertrophy with stress and time and represents another option especially with otherwise insurmountable problems. (5,7,10-11,12,16,17,21,28,29,36) (Fig.9)

Fig 6 a-d An infected tibia in a 41 year old diabetic woman

a) the clinical wound

b) the xray post debridement and the morsalized cancellous graft to be placed

c) the xray post union

d) the clinical appearance of the limb

Fig 6a

Fig 6b

Fig 6c

Fig 6d

Fig 7a

Fig 7b

Fig 7 a-b A chronic wound in a 14 year old boy

a) the xray post debridement and external fixation and post transfer of the ipsilateral fibula on its vascular pedicle

b) the follow-up xrays showing marked hypertrophy of the fibula

Fig 8a

Fig 8 a-e A severe postoperative infection of a proximal tibia fracture with necrotic bone in a 26 year old male

a) the infected wound

b) s/p debridement, free flap by Dr Michael Yaremchuk, and bony transport

c) secondary surgery to gain union at the "docking" site

d) clinical function at 2 years

e) clinical knee function at 2 years

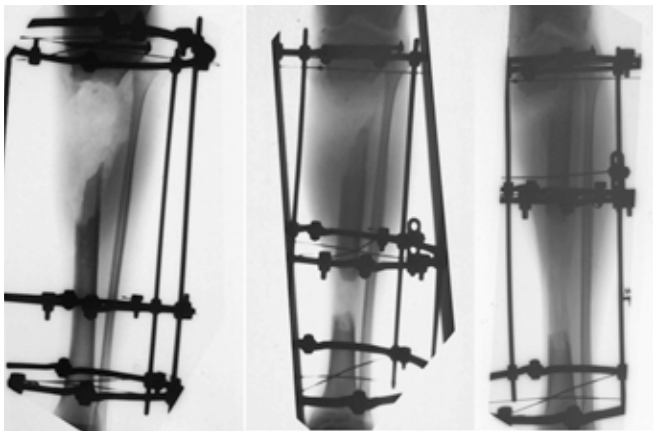


Fig 8b

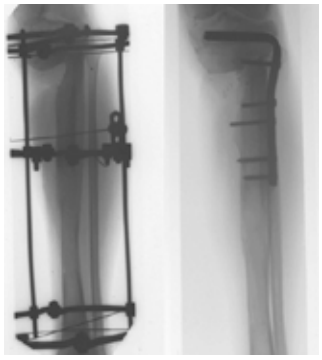


Fig 8c

Fig 8d

Fig 8e

For an Orthopaedic surgeon, the skeletal reconstructive procedures can be a continuous source of learning and incredibly rewarding surgical endeavor as so many patients, faced with profound disabilities or limb ablations, were able to return to a functional life. (1,2,4,22-5,27,30,31-3,38)

Fig 9a

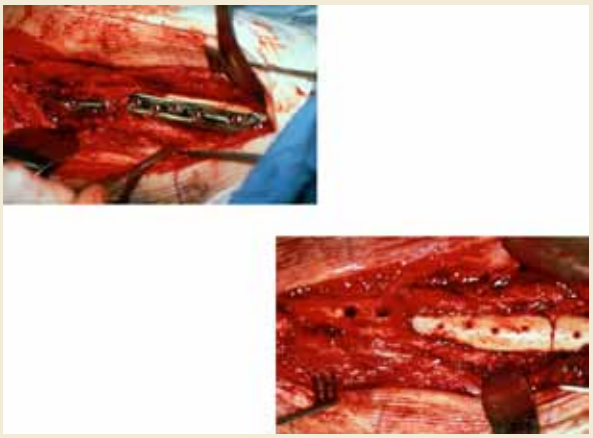


Fig 9b

Fig 9c

Fig 9 a-f A combined infected hip fracture and ipsilateral femoral shaft fracture in a 28 year old male

a) the infected wounds
b) intraoperative appearance of the sequestrum of the femur
c) s/p debridement showing a thin residual involucrum
d) placement of the vascularized fibular transfer
e) one year follow-up xray
f) s/p total hip arthroplasty by Dr Donald Reilly

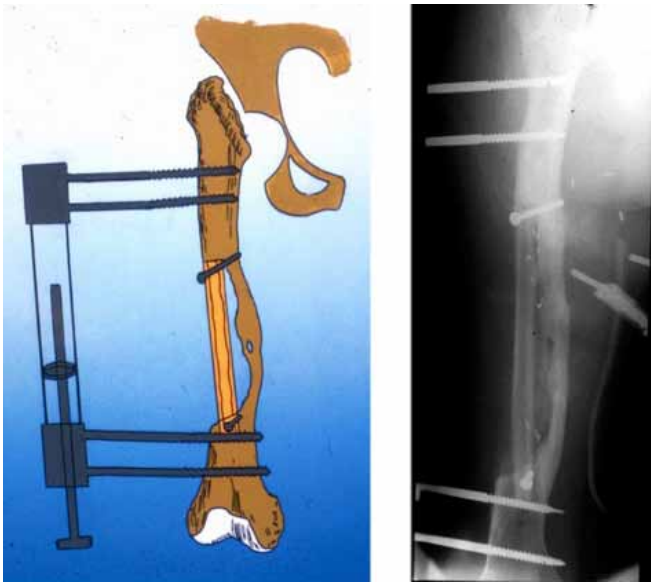


Fig 9d

Fig 9e

Fig 9f

Table 1: Open Cancellous Bone Grafting

Indications:

- Intact but weakened bone
- Limited soft tissue defect
- Proximal and distal tibia
- Septic arthrodesis

Advantages:

- Technically simple
- Bone placed at site of defect

Disadvantages:

- Requires vascular bed
- Delay in wound coverage
- Prolonged time until functional loading

Table 2: Fibula - Pro - Tibia

Indications:

- Defect 6 cm or greater with intact fibula (Type IV)

Advantages:

- Use of ipsilateral bone
- Fibula straight, cortical bone will respond to stress
- Transfer without microvascular technique

Disadvantages:

- Taking the ipsilateral fibula decreases stability
- Cannot be done if the peroneal artery is the only vessel

Table 3: Ilizarov Method

Indications:

- Virtually any combined skeletal and soft tissue defect

Advantages:

- One surgical procedure
- Length of defect no barrier
- Soft tissue envelope no barrier

Disadvantages:

- Time consuming
- Device cumbersome and difficult to apply

Table 4:Vascular Bone Graft

Advantages:

- One surgical procedure
- Extended length
- Carries own circulation
- Can hypertrophy

Disadvantages

- Technically demanding
- Limited donor site
- Microsurgery

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