



Traumatic femoral bone defect reconstruction with an autoclaved autologous femoral segment A 10-year follow-up

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Traumatic bone defects in the diaphyso-metaphyseal distal part of the femur are difficult to treat. Only two publications have described traumatic extrusion of a femoral shaft fragment and its successful replacement after autoclave sterilisation.

We report the case of a 17-year-old patient who had traumatic extrusion of an 11-cm segment of his distal femur. The bone segment was retrieved on the road, and was reimplanted in its anatomical position after cleansing and autoclaving. At ten years follow-up, there is complete incorporation with full functional recovery. The preserved periosteum seems to have played a major part in this successful outcome.

Keywords : traumatic bone defect ; femur ; re-implantation ; autoclaving.

Hospital, after a motorcycle crash. The accident occurred on the small island of Saint-Barthelemy, in the French West Indies, 250 miles north of Martinique. His right femur and tibia were fractured. He was flown over to Martinique and presented five hours later, in good general condition, with a right tibial shaft fracture and a Gustilo type II open distal diaphyso-metaphyseal femoral fracture, and a 5-cm lateral wound at the suprapatellar level. Circulation and nerve supply of the limb were intact. The radiographs showed distal femoral bone loss of uncertain extent (fig 1). Under general anaesthesia, the tibial fracture was fixed with a medullary nail. The suprapatellar wound was closed after debridement and cleansing. A transcalfaneal pin was placed, and skeletal traction was applied to align the distal femoral fracture. An

INTRODUCTION

Traumatic bone defects in the distal part of the femur are difficult to treat. Only two publications (1, 5) have reported traumatic extrusion of a femoral shaft fragment and its successful reimplantation after autoclave sterilisation. We have used this method in the case reported here, and the graft evolution has been followed over ten years.

CASE REPORT

A 17-year-old boy was admitted to the emergency room of Martinique La Meynard University

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Fig. 1. — Open distal diaphyso-metaphyseal femoral fracture with 11-cm traumatic bone loss.

11-cm femoral bone segment was found on the road after the accident ; it was put in a bag, placed in an ice basket and brought to the hospital. This bone segment was washed, cleansed, decontaminated and sterilised by autoclaving at 121° during 20 minutes at 1.3 bars. There was no soft tissue left on the bone fragment, and more specifically no periosteum.

Twenty days after the injury, the wound was completely healed, stitches were removed, and re-implantation of the bone segment with internal fixation of the fracture was performed. The suprapatellar scar was excised and extended proximally and distally to a standard lateral approach. The autoclaved bone segment was inserted back into the distal part of the femur, which restored femoral length and rotational alignment. Internal fixation was made with a long Müller 95° blade plate (fig 2). The retrieved bone fragment was in very



Fig. 2. — Radiograph taken 45 days after internal fixation with a long 95° blade plate.

close apposition to the two main femoral fragments, and was solidly fixed with screws to the plate. There was no residual bone gap, and autologous iliac grafting was judged unnecessary. Postoperatively antibiotics were continued for 10 days. The patient's postoperative course was uneventful. He had slightly elevated temperature for the first two days, then his temperature returned to normal. Wound healing was normal and stitches were removed after 20 days.

The patient was extremely cooperative, and began immediate physiotherapy, with quadriceps exercises and active and passive knee motion. Weight bearing was postponed for 3 months and a

full range of active motion of the knee without any recurvatum was obtained. Active squatting and heel sitting was easily done. There was no leg length discrepancy, no malrotation, no varus or valgus malalignment. Return to sports activities (jogging, windsurfing and surfing) was possible after 6 months.

Radiographs were taken after 1.5 months and 4 months, then yearly up to 10 years ; they showed no discontinuity between the re-implanted bone fragment and the femur. After two years, there was complete healing at the two fracture lines (fig 3).

After seven years, there were no radiological changes in the massive autologous graft. Removal of the plate was performed. During this procedure biopsy at the metaphyseal-graft junction between the graft and the lateral condyle showed a normal osseous structure. One month later he recovered full knee mobility and returned to sports activities as previously. At ten years, he continues to practice sports.

DISCUSSION

The case reported is comparable to those previously reported by Kirkup (5) and Abell (1), in which the patella was also fractured. Their follow-up was only 2 and 2.5 years. An important point in the case reported here was that the periosteum had remained attached to the surrounding soft tissue. Strange (14) reported full bone reconstruction following conservative management after extrusion of a full-diameter, three-inch long femoral shaft segment. He also stated that "given a periosteum tube, loss of bone does not necessarily infer non-union, and healthy periosteum will replace bone throughout its length in the same way that scars heal, irrespective of their length".

Simple prolonged traction might have been sufficient to restore the 11-cm femoral gap in our case, but this approach would not have allowed early mobilisation. Indeed only a medial bony bridge appeared on radiographs after 1.5 month and it remained unchanged for 7 years. It would not have been strong enough to allow full weight bearing, and a graft would have been necessary to reconstruct the femur (fig 1, 2 and 3).

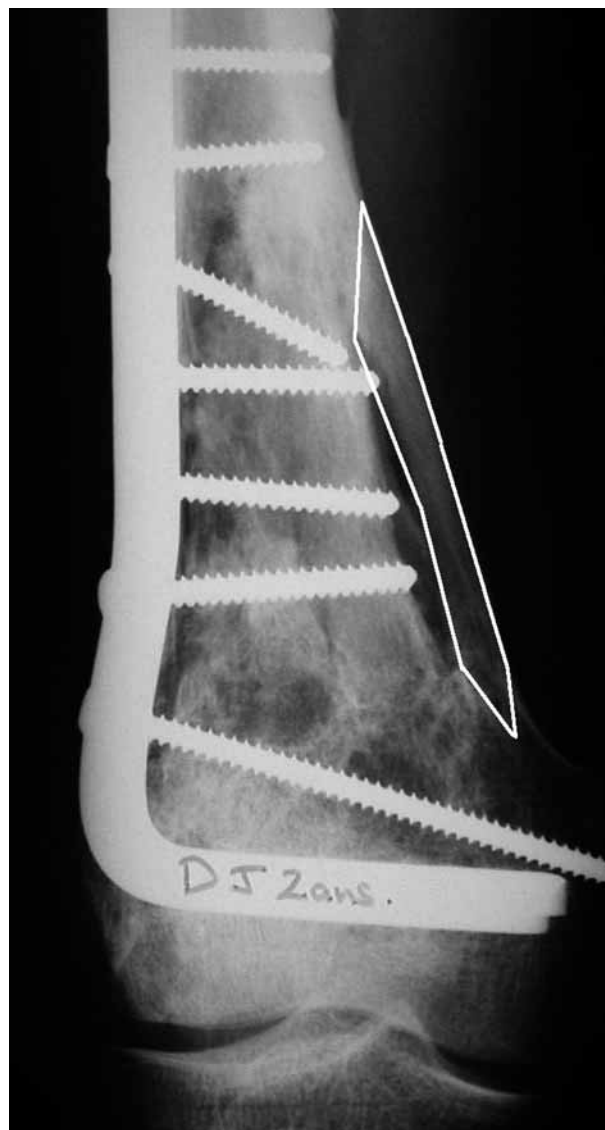


Fig. 3. — Bone healing at two years at the two junction sites : diaphysis-graft and graft-metaphysis, with development of a periosteal bony bridge (outlined) on the medial side of the graft at two years.

Moukoko *et al* (9) reported osteoblastic proliferation after a periosteal vascularised graft in rabbits. Local stimulation of the periosteum by a fracture or callotaxis can lead to osteoblastic proliferation.

Kohler and Kreichbergs (6, 7) resected a segment of ulna and humerus in rabbits. The gap was filled on one side with allogeneic bone, and on the contralateral side with autoclaved autologous bone.



Fig. 4. — Radiograph after ten years (3 years after plate removal) ; there is no osteolysis in the graft.

When the graft was supplemented with allogeneic bone matrix, abundant new bone formation and complete incorporation of all implants was noted after 16 weeks. When the grafts were not supplemented, new bone formation was poor, non-union occurred in three out of seven autoclaved re-implantations and in five out of seven allogeneic transplantations. Taguchi *et al* (15) also reported that enhancement of new bone formation by bone marrow is probably more important than the type of non-viable bone graft chosen for reconstruction of large skeletal defects.

Radiography and even MRI appear inadequate to precisely indicate the progress of osseous bone formation. Only histological analysis can confirm it. Massin *et al* (8) reported the results of cortico-cancellous frozen allografts, autoclaved autografts and autoclaved allografts implanted in the lower femoral metaphysis of 18 dogs. The overall radio-

logical results were satisfactory, suggesting graft fusion to the host bone. Histological results were inferior to roentgenographic results, and showed only minimal signs of bone formation at the periphery of the graft. No difference was found between autoclaved and non autoclaved allografts.

Nevertheless radiography is currently the only non-invasive investigation to monitor bone evolution. In some reconstructions with massive irradiated allograft, osteolytic zones become apparent in the graft after five years, suggesting poor mechanical properties. Usually, in young patients, plate removal is performed after one or two years. In our case, a minimum of 5 years was requested before plate removal. It took place after 7 years. There were no modifications on radiographs, and a biopsy done at the metaphysis-graft junction showed histologically normal bone. The patient continued to practice sports, and no fracture occurred over three years after plate removal.

The good clinical result achieved can be explained by the persistence of the periosteum and also by the sterilisation process of the graft.

Gamma radiation is a very safe procedure, but is difficult to use in most hospitals ; furthermore it is a very aggressive process which can generate fat peroxidation in the graft. Macrophagic reactions have been reported, with osteolysis of the bone graft.

Schratt and Spyra (13) compared, in rats' tibias, the immunologic response to irradiated, autoclaved and cryo-preserved allografts. An important cell-mediated immune response was observed with irradiated and frozen allografts, but not with autoclaved allografts.

Autoclave sterilisation at 120°C during 20 minutes at 1.3 bar can be effective to eliminate all pathogens except prions and HIV, which necessitate 130°C and 1.6 bar to be destroyed (3).

Pasteurisation is a very new sterilisation process necessitating only heating at 60°C during 30 minutes. Zoricic *et al* (16), in rabbits' ulnas, reported that frozen and pasteurised allografts induced osteo-inductive processes , but autoclaved grafts did not.

Asada *et al* (2), Bohm *et al* (4), Panet *et al* (10), Sanjay *et al* (12), reported that massive autologous

autoclaved grafts give good results in reconstruction of bone tumours. This technique can be very effective with minimal cost even in developing countries (11). Most of the time extruded loose bone fragments are not used for replacement. This case documents the fact that the use of a sterilised autologous fragment can be successful, with full functional recovery. The persistence of the periosteum was probably essential for the development of a periosteal bridge on the medial side of the metaphysis and the final positive outcome. This case underlines the necessity to preserve the periosteum in fracture treatment. Further research should explain how the periosteum can control the osteoblastic formation process.

REFERENCES

1. **Abell CF.** Extrusion of femoral shaft fragment by trauma and successful replacement. A case report. *J Bone Joint Surg* 1966 ; 48-A : 537-541.
2. **Asada N, Tsuchiya H, Kitaoka K, Mori Y, Tomita K.** Massive autoclaved allografts and autografts for limb salvage surgery. A 1-8 year follow-up of 23 patients. *Acta Orthop Scand* 1997 ; 68 : 392-395.
3. **Blech MF, Benoit F.** La stérilisation des dispositifs médicaux. Prévention des infections en chirurgie orthopédique et traumatologique. *Tiresias* Paris, 2^o édition 2001, vol 1.
4. **Bohm P, Springfield R, Springer H.** Re-implantation of autoclaved bone segments in musculoskeletal tumor surgery. Clinical experience in 9 patients followed for 1.1-8.4 years and review of the literature. *Arch Orthop Trauma Surg* 1998 ; 118 : 57-65.
5. **Kirkup JR.** Traumatic femoral bone loss. *J Bone Joint Surg* 1965 ; 47-B : 106-110.
6. **Kohler P, Glas JE, Larsson S, Kreicbergs A.** Incorporation of nonviable bone grafts. Autoclaved autogenic and frozen allogeneic bone grafts compared in the rabbit. *Acta Orthop Scand* 1987 ; 58 : 54-60.
7. **Kreicbergs A, Kohler P.** Diaphyseal reconstruction by autoclaved bone. Reimplantation experiments in rabbits. *Acta Orthop Scand* 1987 ; 58 : 61-65.
8. **Massin P, Bocquet L, Hutten D et al.** Radiographic and histologic observations of autoclaved and non autoclaved allografts in the distal femoral metaphysis in dogs. *Rev Chir Orthop* 1995 ; 81 : 189-197.
9. **Moukoko D, Pourquier D, Dimeglio A.** Stimulation des cellules souches mésenchymateuses in vivo dans un modèle animal de régénération du tissu squelettique. *Rev Chir Orthop* 2003 ; 89, Suppl 6 : 206, 3S117.
10. **Pan KL, Mourougayah V, Jayamalar T.** Squamous cell carcinoma involving the tibia treated by reimplantation of autoclaved resected bone. *Med J Malaysia* 2003 ; 58 : 783-785.
11. **Rao H, Patil SR.** Traumatic extrusion and replacement of autoclaved diaphyseal segment of radius : a case report. *Hand Surg* 2004 ; 9 : 221-224.
12. **Sanjay BK, Moreau PG, Younge DA.** Reimplantation of autoclaved tumour bone in limb salvage surgery. *Int Orthop* 1997 ; 21 : 291-297.
13. **Schratt HE, Spyra JL.** Experimental studies of healing and antigenicity of sterilized bone transplants. *Chirurg* 1997 ; 68 : 77-83.
14. **Strange FG.** Union of fractures. *Lancet* 1963 ; 9 : 305-307.
15. **Taguchi Y, Pereira BP, Kour AK, Pho RW, Lee YS.** Autoclaved autograft bone combined with vascularized bone and bone marrow. *Clin Orthop* 1995 ; 320 : 220-230.
16. **Zoricic S, Bobinac D, Lah B et al.** Study of the healing process after transplantation of pasteurized bone grafts in rabbits. *Acta Med Okayama* 2002 ; 56 : 121-128.