# 13 Treatment of Avascular Femoral Head Necrosis with Bone Morphogenetic Protein, a Collagen Scaffold and Filtered Autologous Mesenchymal Stem Cells

Georgio Maria Calori and Peter V. Giannoudis

## Indications

- Osteonecrosis of the femoral head (up to Stage IIIC of the Steinberg classification system).
- Patients under 55 years of age.
- No presence of radiological-documented arthritis of the hip.
- Nom BMP hypersensitivity.
- No underlying pregnancy.

## Preoperative Planning

### Clinical Assessment

- Pain is the first symptom. It is localized in the affected hip site with possible radiation of pain to the knee, often without related radiographical signs. Causes of early pain are: tissue ischemia, pressure increase inside the bone, microfractures in the avascular zone.
- Investigate any concomitant systemic disease (obesity, smoke, alcohol abuse, rheumatic disease, cancer, acute and chronic leukemia, sickle-cell disease).

### Radiological Assessment

- Anteroposterior (AP) and lateral X-rays of the affected hip (Fig. 13.1).
- Magnetic Resonance Imaging (MRI) to determine the exact size and position of the lesion in early stages. It allows to find the early trasformation of the hematopoietic marrow in fat marrow individuating those patients with higher risk before the lesion of the femoral head takes place (Fig. 13.2).

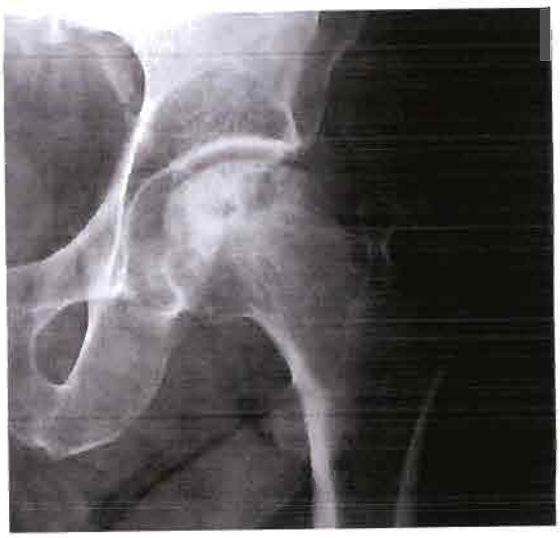


Fig. 13.1 Anteroposterior (AP) radiograph of the affected hip (radiographic changes can appear even up to 6 months after pain onset)

G.M. Calori (✉)
Academic Department of Trauma and Orthopaedic Surgery, Instituto Ortopedico Gaetano Pini, Milan University, Milan, Italy
e-mail: gmc@studiocalori.it

P.V. Giannoudis
Academic Department of Trauma and Orthopaedic Surgery, School of Medicine, University of Leeds, Leeds, UK

P.V. Giannoudis (ed.), *Practical Procedures in Elective Orthopaedic Surgery*,
DOI 10.1007/978-0-85729-814-0_13. 

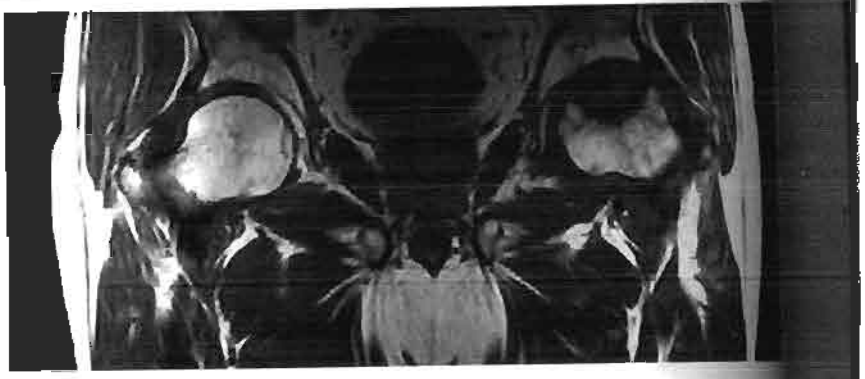


Fig. 13.2 Magnetic Resonance Imaging (MRI) showing the exact size and position of the AVN lesion in the left hip

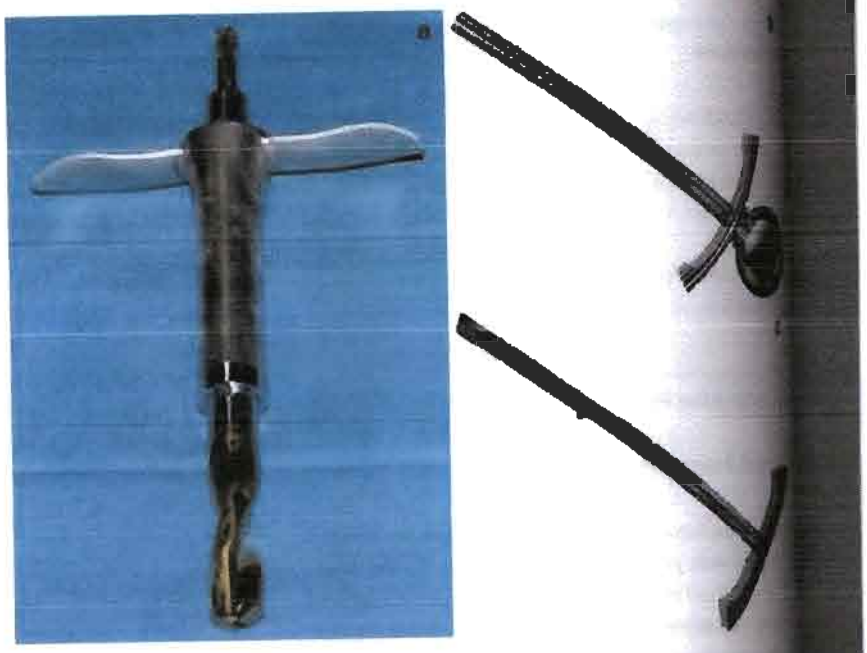


Fig. 13.3 (a) 14-mm-diameter cannulated reamer and cannulated guide designed for the reamer. (b, c) Cannula with reservoir for BMP-7 with pushing device

## Operative Treatment

### Anesthesia

- Regional (spinal/epidural) and/or general anesthesia.
- At induction, administer short-therapy prophylactic antibiotic as per hospital protocol (e.g., first generation cephalosporin).

### Table and Equipment

- Instrumentation set including guide wire, 14-mm diameter cannulated reamer, cannulated guide designed for the reamer (Fig. 13.3a), cannula with reservoir for BMP-7 with pushing device (Fig. 13.3b, c).
- A radiolucent table or a fracture table with appropriate traction devices.
- An image intensifier or CT equipment.
- Bone marrow aspiration trocar for harvesting Mesenchymal Stem Cells (MSC's).
- A bone marrow concentration device.
- A collagen scaffold.

### Table Setup

- The instrumentation is set up on the side of the operation
- Image intensifier is from the contralateral side.

b

c

nula with reservoir for
Fig. 13.3b, c).
racture table with the

quipment.
rocar for harvesting
SC's).
device.

he side of the operation.
ontralateral side.



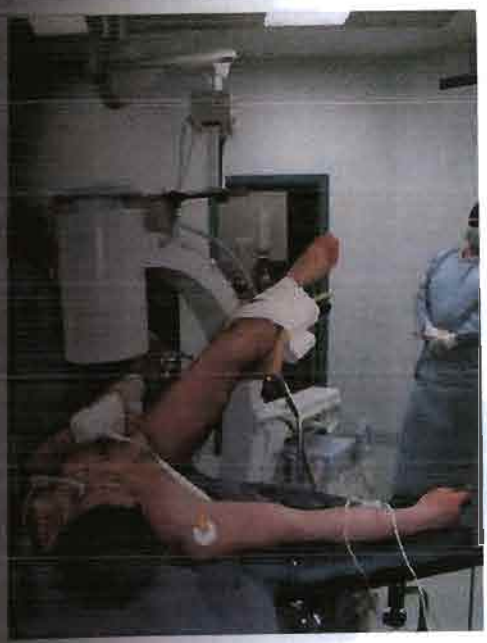


Fig. 13.4 Patient supine with the injured leg positioned in a footplate attached to the leg extensions of the fracture table. Contralateral leg in a leg holder in wide abduction with adequate padding over the peroneal nerve

## Patient Positioning

- Supine with the affected leg positioned in a footplate attached to the leg extensions of the fracture table (Fig. 13.4).
- Position the opposite leg in a leg holder in wide abduction with adequate padding over the peroneal nerve.

## Iliac Crest Harvesting

- Clean the skin around the iliac crest with the usual antiseptic solutions (10% povidone-iodine solution, chlorhexidine gluconate, 4%).
- Identify the Anterior Iliac Crest (AIC) by locating the center of prominence of anterior superior iliac spine, just under lip of crest chosen site.
- Highlight the procedure site with an indelible pen.
- Place a sterile drape with a fenestrated opening over the AIC.
- Fill the necessary number of 30-mL syringes (added with heparin solution or other anticoagulant). Usually at least 60 mL of bone marrow aspirate is required.

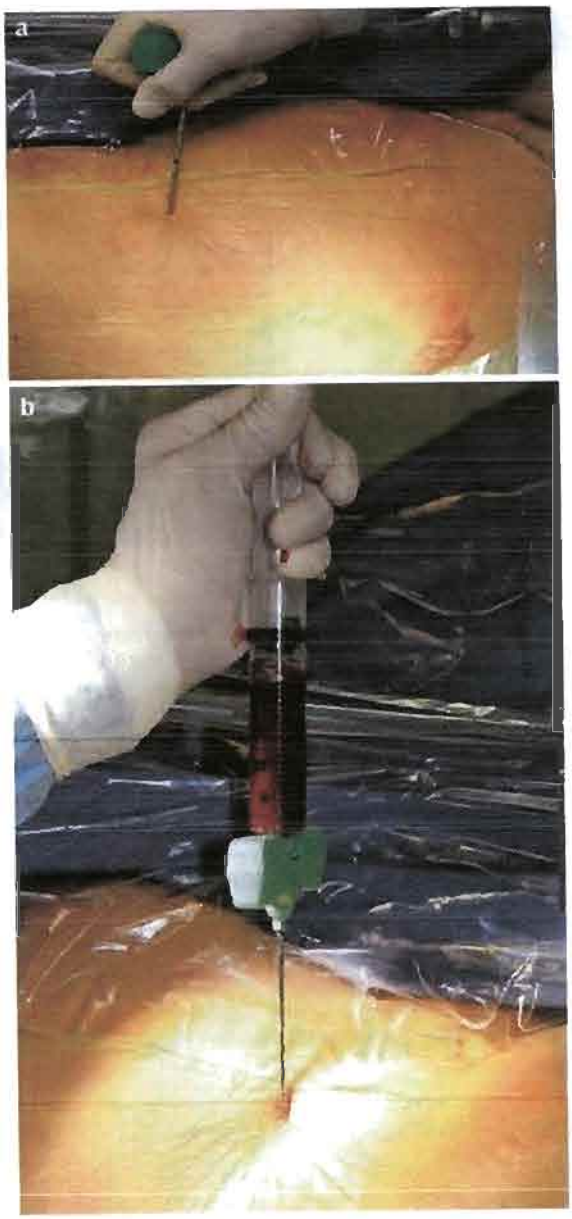



Fig. 13.5 (a) Punctioning of the skin vertically over the Anterior Iliac Crest. (b) Attaching the syringe to the needle and aspiration of the marrow into the syringe until is filled

- Hold aspiration needle vertically to puncture the skin. Press the needle with a slight twisting motion through the cortical bone and advance it about 1 cm into the marrow cavity. Unlock and remove the obturator (Fig. 13.5a, b).

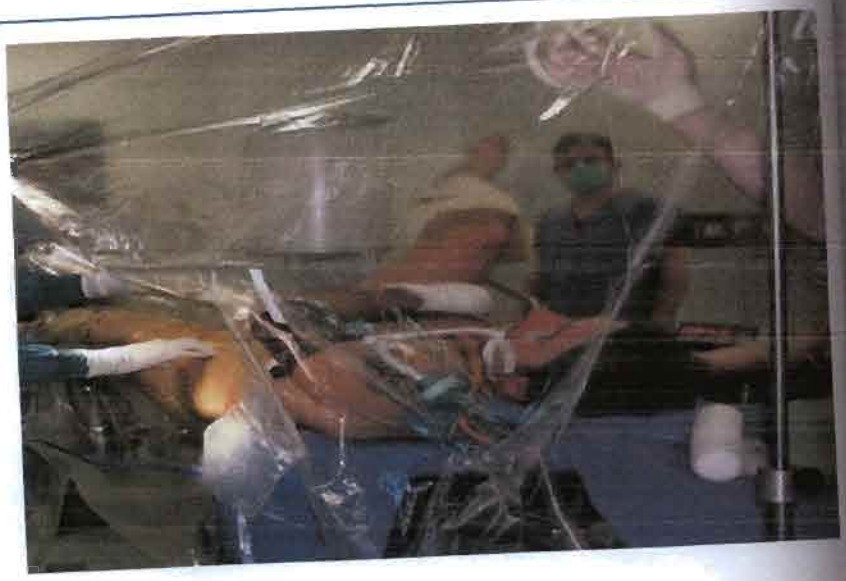


**Fig. 13.6** Application of a transparent, plastic, adherent isolation drape directly over the proposed incision site

- Attach a 30-mL syringe to the needle and aspirate marrow into the syringe until it is fullfilled. Repeat the procedure until all two syringes are filled. Give the material collected to the technical assistant to process them.
- If not enough harvest can be obtained from the procedure site, then reposition needle changing depth, angle, or location until harvesting is successfull. Try the contralateral side if necessary.
- Remove aspiration needle and achieve hemostasis. Suture skin if necessary and cover with a sterile dressing.
- Concentrate the bone marrow aspirate as per instructions of the bone marrow concentration device (usually a volume between 6-8mls is obtained).

## Draping and Surgical Approach

- Prepare the skin over the proximal femur with antiseptic solution.
- Apply a transparent, plastic, adherent isolation drape directly over the proposed incision site (Fig. 13.6).
- Perform a mid-lateral longitudinal incision, extending distally from the great trochanter for 1.5–2 cm (Fig. 13.7). Divide the fascia lata and the vastus lateralis muscle in line with the skin incision.

## Core Decompression

- Place the guide wire into the center of the necrotic area of the femoral head under fluoroscopic or CT control (Fig. 13.8a, b). Check the position of the wire in the AP and lateral planes.
- Determine the reaming distance using the measuring device.
- Ream coaxially the femur with 14-mm-diameter cannulated reamer under image intensifier control to confirm that the guide wire is not advancing into the pelvis up to 1 cm from the chondral surface (Fig. 13.9a, b).
- Remove bone up to the subchondral level in order to achieve core decompression (Fig. 13.10).

**Fig. 13.7** Mid-lateral longitudinal incision, extending distally from the great trochanter for 1.5–2 cm

## Graft Positioning

- Prepare a scaffold of cancellous bone permeated with autogenous filtered bone marrow cells. The scaffold is a decalcified, flexible, and mouldable equine bone



**Fig. 13.8** (a, b) Placi necrotic area of the f control

tissue with coll with filtrated bo

- Apply BMP-7 active substance reservoir of the c from the reservo
- Insert the scaffc tation under flu reaches the sub the scaffold en affected AVN a contains the (Fig. 13.11c).
- Obtain final flu AP and lateral

inal incision, extending distally
–2 cm

Check the position of the
l planes.
distance using the measur

ur with 14-mm-diameter
image intensifier control
wire is not advancing into
rom the chondral surface

ubchondral level in order
ssion (Fig. 13.10).

llous bone permeated with
narrow cells. The scaffold
d mouldable equine bone

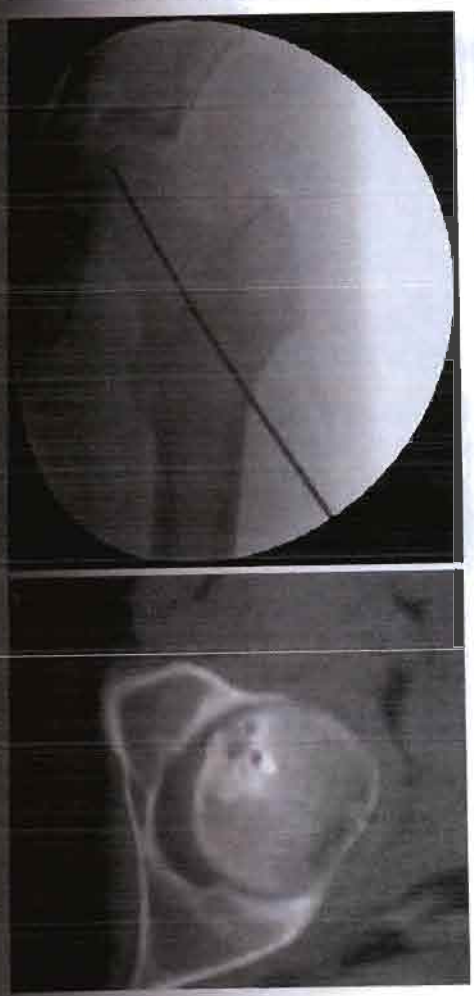


Fig. 13.8 (a, b) Placing of the guide wire into the center of the necrotic area of the femoral head under fluoroscopic or CT control

bone with collagen, which expands after loading with filtrated bone marrow cells (Fig. 13.11a).

- Apply BMP-7 following preparation (dilution of active substance with 2.5 ml of normal saline) on the reservoir of the cannula. Advance BMP-7 at least 2 cm from the reservoir inside the tunnel of the cannula.
- Insert the scaffold using the appropriate instrumentation under fluoroscopic guidance until the implant reaches the subchondral plate (this advancement of the scaffold ensures delivery of the BMP into the affected AVN area and at the same time the scaffold contains the protein within the femoral head) (Fig. 13.11c).
- Obtain final fluoroscopic or CT imaging in both the AP and lateral views (Fig. 13.11d, e).

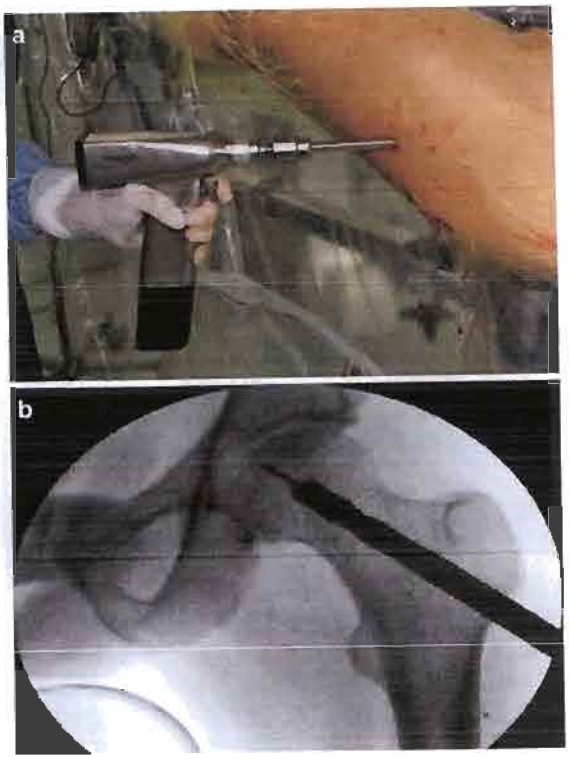



Fig. 13.9 (a, b) Reaming coaxially the femur with a 14-mm cannulated reamer under image intensifier control to confirm that the guide wire is not advancing into the pelvis

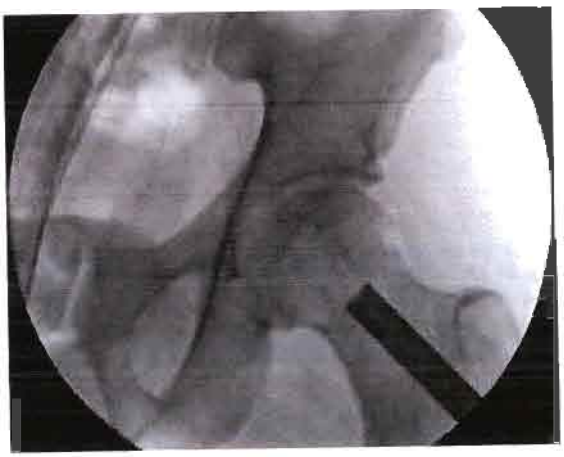


Fig. 13.10 Removing of bone up to the subchondral level in order to achieve core decompression

## Closure

- Irrigate the wound thoroughly and achieve hemostasis.

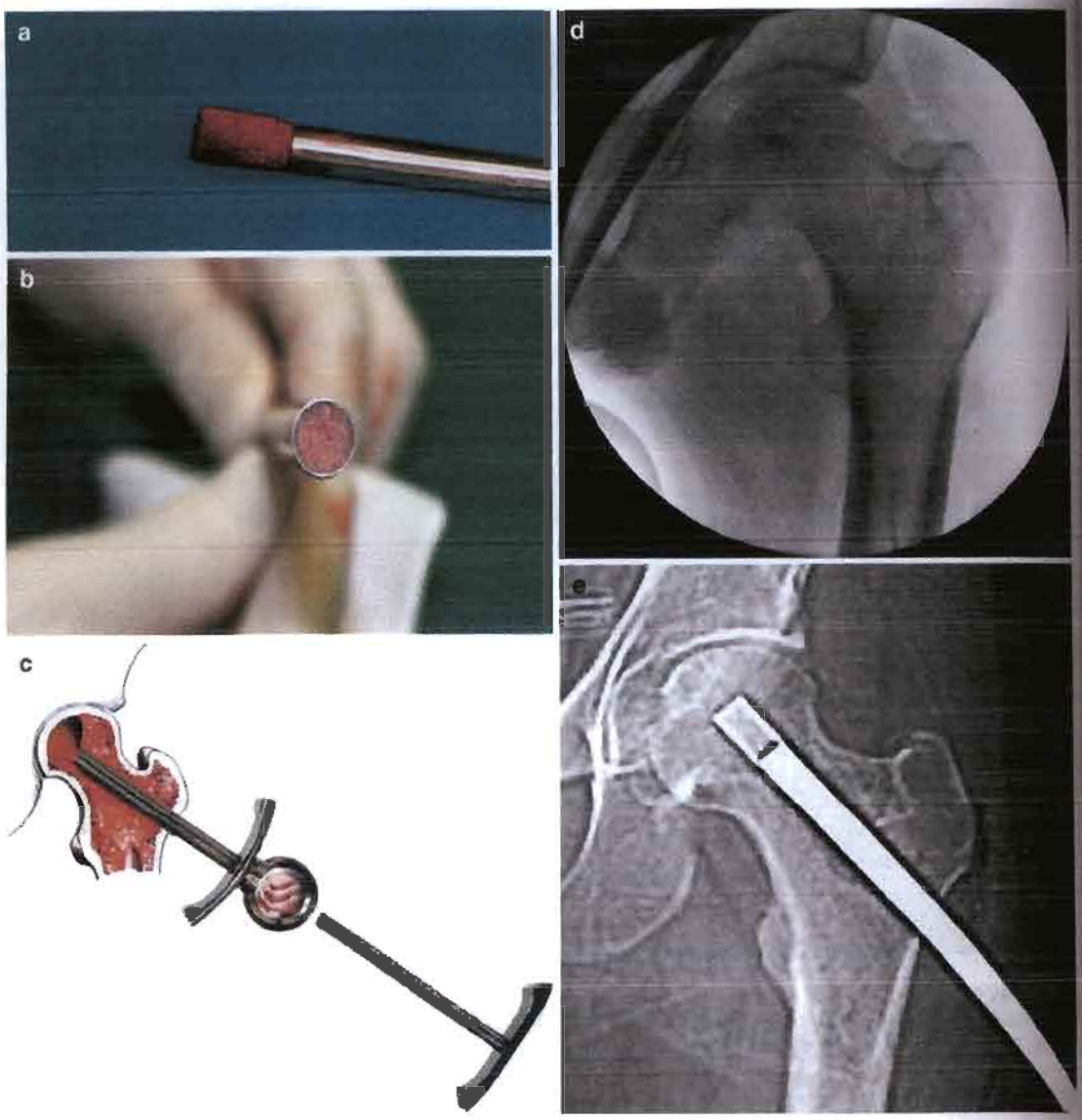



**Fig. 13.11** (a) Preparation of a cancellous bone scaffold permeated with autogenous filtered bone marrow cells. (b) Application of BMP-7 onto the reservoir and advancement of BMP-7 inside the tunnel of the trochar by at least 2cm. (c) Insertion of the scaffold using the appropriate instrumentation under fluoroscopic guidance. (d, e) Final control with fluoroscopic or CT imaging

- Close the fascia lata and the subcutaneous fat with adsorbable sutures.
- Skin closure and covering with sterile dressing.

## Postoperative Rehabilitation

- Obtain Postoperative radiographs.
- Routine blood examination.
- Two more doses of antibiotics.
- Prescribe thromboprophylaxis for a period of 6 weeks as per local department protocol.
- Non-weight-bearing with use of crutches for 3 weeks, then mobilize partial weight-bearing (20–25% of the overall weight) for 3 weeks, and then progressive weightbearing for 6 weeks with physiotherapy assistance.



Fig. 13.12 (a) CT control 6 months after operation, documenting partial bone formation in the former necrotic area. (b) Radiographic control 12 months after surgery documenting absence of he deformation with complete bone formation

## Outpatient Follow

- Review after 1 mont then every 3 months f for the second year, t
- Evaluate at the 6-m by using Harris Hip

## Further Reading

Garrigues GE, Aldridge 3 ized fibular grafting f femoral head secondar 2009;29(5):342–5.

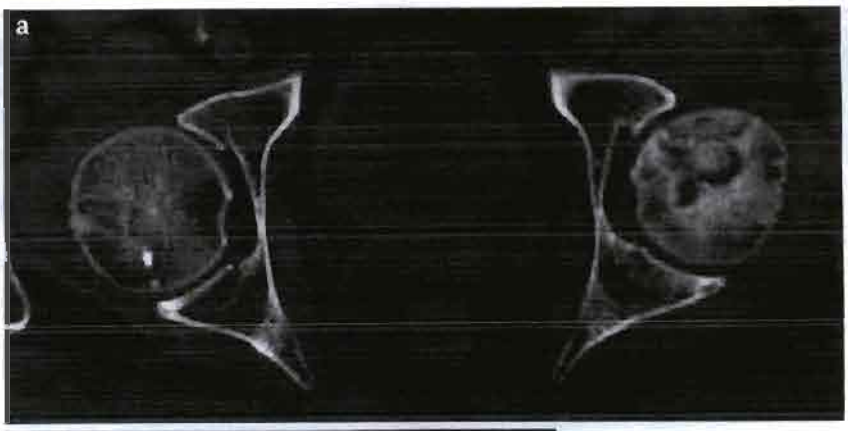
m. (c) Insertion of the scaffitation under fluoroscopic oroscopic or CT imaging

cs.

for a period of 6 weeks as

of crutches for 3 weeks, t-bearing (20–25% of eeks, and then progreseks with physiotherapy





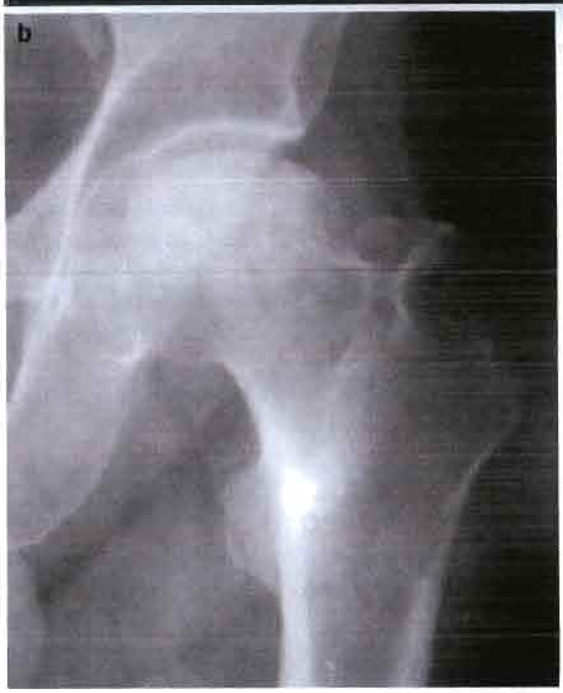




Fig. 13.12 (a) CT control 6 months after operation, documenting partial bone formation in the former necrotic area. (b) Radiographic control 12 months after surgery documenting absence of head deformation with complete bone formation

## Outpatient Follow-Up

- Review after 1 month with radiographs of the hip and then every 3 months for the first year, then every 6 month for the second year, then once a year (Fig. 13.12a, b).
- Evaluate at the 6-months and 12-months follow-up by using Harris Hip Score.

## Further Reading

Garrigues GE, Aldridge 3rd JM, Friend JK, et al. Free vascularized fibular grafting for treatment of osteonecrosis of the femoral head secondary to hip dislocation. Microsurgery. 2009;29(5):342–5.

Aldridge 3rd JM, Urbaniak JR. Avascular necrosis of the femoral head: role of vascularized bone grafts. Orthop Clin North Am. 2007;38(1):13–22.

Yen CY, Tu YK, Ma CH, et al. Osteonecrosis of the femoral head: comparison of clinical results for vascularized iliac and fibula bone grafting. J Reconstr Microsurg. 2006;22(1):21–4.

Tang CL, Mahoney JL, McKee MD, et al. Donor site morbidity following vascularized fibular grafting. Microsurgery. 1998;18(6):383–6.