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

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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.
- No 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 insascular zone.
- Investigate any concomitant systemic disease (obesity, smoking, alcohol abuse, rheumatic disease, cancer, autoimmune 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 transformation of the hematopoietic marrow in fat marrow individualizing these 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)
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 according to 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 operating table.
- Image intensifier is from the contralateral side.
Patient Positioning

- Anesthetize 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 packing over the peroneal nerve.

Iliac Crest Harvesting

- Clean the skin around the iliac crest with the usual anesthetic 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) Pin puncturing 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 it 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).
- 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 successful. 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 antisepctic 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).

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 tissue with collagen fibrils, immersed with filtrated bone marrow aspirate.
- Apply BMP-7 active substance from the reservoir of the culture device.
- Insert the scaffold under fluoroscopic control until the scaffold reaches the subchondral bone. The scaffold ends at the affected AVN area (Fig. 13.11a, b).
- Obtain final fluoroscopic control in AP and lateral planes.
Check the position of the guidewire using the measurement obtained from the radiographic images. Ensure the guidewire is perpendicular to the subchondral bone.

Place the guide wire into the center of the femoral head under fluoroscopic or CT guidance.

Place the scaffold using the appropriate instrumentation under fluoroscopic guidance until the implant reaches the subchondral plane. This advancement of the scaffold ensures delivery of the BMP into the affected AVN area and at the same time the scaffold ensures the protein within the femoral head.

FIG. 13.9 (a, b) Coring 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 absorbable 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 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 weight-bearing for 6 weeks with physiotherapy assistance.

Outpatient Follow-up

- Review after 1 month and then every 3 months for the second year,
- Evaluate at the 6th month by using Harris Hip Score.

Further Reading

Treatment of Avascular Necrosis of Femoral Head with BMP, a Scaffold and MSCs

**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**


