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BONE GRAFTS AND BONE GRAFT SUBSTITUTES IN PROSTHETIC HIP SURGERY REPLACEMENT

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The need for bone grafting procedures to replace skeletal defects has become more considerable because of increased opportunities to save major bone loss. We report our experience and a critical analysis about the role of bone grafts and bone graft substitutes in prosthetic hip surgery replacement.

Total hip replacement surgery is performed more often, but every year about 17% of the first implants require a subsequent revision surgery (1), with a higher prevalence in women with a ratio of 1.9>1.3 and average age of 73> 72 F> M. These patients generally complain coxalgia and / or back pain, with severe functional limitation or even complete functional impotence. There are several causes that lead to a prosthetic replacement: 70-94% aseptic loosening; infections (3-9%) (2); recurrent dislocations (2-10%). In 73% both components require revision, the acetabular component alone is involved in 40% and in 22% the femoral stem. The aim of the surgeon is to preserve the limb function and to restore the bone stock and the biomechanics of the hip. It is necessary to examine the treatment options for the patients with periprosthetic bone loss, discussing the role of bone substitutes (3) and the benefits resulting from their use.

MATERIALS AND METHODS

Our past experience led us to introduce, from January 2009, the bone substitutes in prosthetic revision surgery. Infact, in many patients a good bone stock was not possible to recreate. Therefore the revision cups (Trabecular Metal), the acetabular reinforcement ring (Muller and Burch-Schneider, Fig.1) (4) and the revision stems (S-rom) were used togheter with the synthetic bone substitutes. Bone grafts and bone grafts sobstitutes were utilized in critical bone defects and in small bone defects. Classifications of Paprosky (5) and GIR (6) were used in order to choose the correct treatment.

RESULTS

The patients were clinically evaluated with Harris Hip Score. In our experience, the integration of

the bone substitutes in the hip revision surgery, allowed to perform the revision of prosthesis also in the presence of critical bone defects and to restore quickly the original bone stock .

DISCUSSION

The review of hip replacement is an inevitable solution in cases of functional limitation and pain of the hip. The age, the polypathology and the pharmacological therapy associated, make difficult to manage these patients. X-ray, CT and / or MRI (with and without contrast) are necessary for a pre-operative planning. The surgical approach is very complicated. The direct lateral approach (Hardinge-Bauer), in accordance with a "tissue sparing surgery", allows to remove a prosthetic component, with a reduced risk of dislocation and neurovascular trauma, and provides a good visibility of the acetabulum. In some cases, it is necessary to resort to the ilio-inguinal approach, which lets to an excellent view of the acetabulum (7) and a safe removal of the acetabular component. In our experience, sometimes, the replacement of the acetabular intrapelvic mobilized component (8,9,10) were performed in a single step, by lateral direct approach. The bone defect is an important limitation for bone structural stability in prosthetic hip surgery replacement. The synthetic bone substitutes (collagen-hydroxyapatite "RegenOSS" Fig. 2a) were used in supportive bone defects (Paprosky type I and IIA, IIB and IIC, GIR grade I and II). In non supportive bone defects (Paprosky type IIIA and IIIB, GIR grade III e IV) were used autologous or heterologous bone graft

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Table I. *Bone graft and graft substitutes*

Class	Description	Examples	Properties of action
Autograft based	Used alone	Cancellous, Cortical	•Osteoconductive • Osteoinductive • Osteogenic
Allograft based	Allograft bone used alone or in combination with other materials	Cancellous, Cancellous chips, Cortical DBM	• Osteogenic • Osteoinductive
Factor based	Natural and recombinant growth factors used alone or in combination with other materials	TGF-β, PDGF, FGF, BMP	• Osteoinductive •Both osteoconductive and osteoinductive with carrier materials
Cell based	Cells used to generate new tissue alone or seeded onto a support matrix	Mesenchymal stem cells	•Osteogenic •Both osteogenic and osteoconductive with carrier materials
Ceramic based	Includes calcium phosphate, calcium sulfate, and bioactive glass used alone or in combination	Osteograf, , Osteoset, NovaBone, Actifuse,	•Osteoconductive •Limited osteoinductive when mixed with bone marrow
Polymer based	Includes degradable and nondegradable polymers used alone and in combination with other materials	Cortoss, OPLA, Immix	•Osteoconductive •Bioresorbable in degradable polymer
Miscellaneous	Coral HA granules, blocks and composite	ProOsteon	•Osteoconductive • Bioresorbable

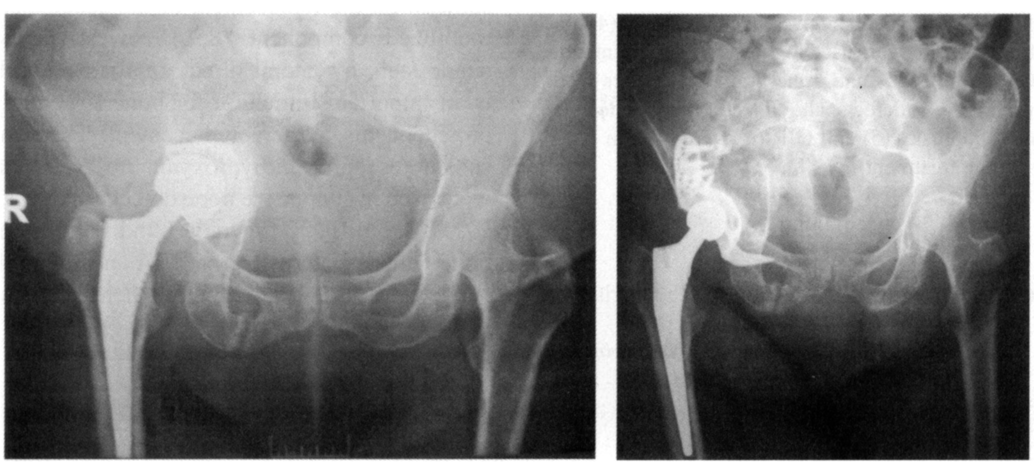

Fig.1: *a) Pre-operative X-ray: intrapelvic migration of acetabular cup; b)Post-operative X-ray: Burch-Schneider, collagen-hydroxyapatite and DBM.*

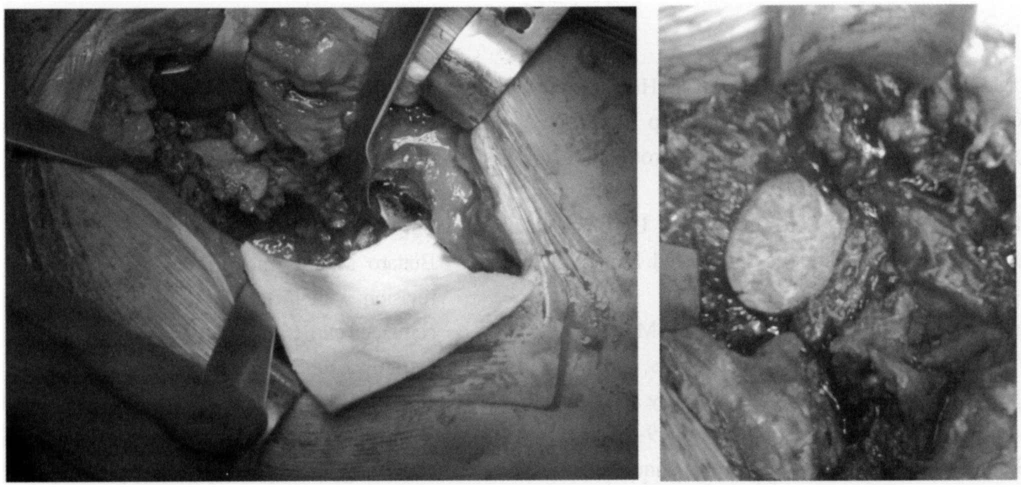

Fig.2. *Intraoperative images: a) collagen-hydroxyapatite; b) equine bone.*

(equine bone, Fig. 2b) which immediately allow to restore a strong bone structure and a stable implant.

The prosthetic hip surgery replacement in proximal femur present several methods: structural allografts, calcar allografts, impaction (11) bone graftings, massive allografts, bone graft substitutes, hybrid graft and allograft prosthetic composites. Cortical bone grafts were used reliably to reconstruct the non-segmental circumferential defects (calcar allograft). There are different types of grafts and bone substitutes (3) and they include a great variety of materials, classificated by Laurencin et al. (Table I)

A. Harvested bone grafts: the endogenous or exogenous bone grafts are essential to provide support, to correct macroscopically and immediately, the bone defect, and to enhance the biological repair of the traumatic or non-traumatic skeletal defects. The limitations of using endogenous bone autografts, derive from the donor site morbidity and from the limited availability, while reducing the risk of disease transmission and immune-mediated interactions. Therefore, there is an increasing need for synthesis of synthetic bone substitutes used alone or in combination with the other materials. B. Allograft based: Allograft bone used alone or in combination with other materials (12,13) C. Growth factor-based bone graft substitutes: natural and recombinant growth factors used alone or in combination with other materials, such as the transforming growth factor-beta (TGF-beta), the platelet derived growth factor (PDGF), the fibroblast growth factor (FGF) and the bone morphogenetic protein (BMP). D. Cell-based bone graft: the cells are used to generate new tissue alone or seeded onto a matrix of support (eg, mesenchymal stem cells) (14). E. Ceramic-based bone graft substitutes: include calcium phosphate, calcium sulfate, and bioglass, used alone or in combination.

F. Polymer-based bone graft substitutes: non-degradable and degradable polymers are used alone or in combination with other materials involved in the generation of bone (eg, mesenchymal cells and osteoblasts). G. Miscellaneous: Several biomaterials marine (coral, chitosan) not conventional, are also used as bone substitutes. The bone substitutes can also be divided into osteoinductive, osteoconductive and osteogenic agents:

• osteoinductive agents: they are generally proteins which induce proliferation or differentiation of stem cells or they help the undifferentiated stem cells to become osteogenic cells. (rh-BMP-7, rh-BMP-2) (15,16);

• osteoconductive agents: they can act as a scaffold to facilitate the microscopic and macroscopic inward migration of cellular elements involved in the formation of the bone (mesenchymal stem cells and osteoblasts) (13).

• osteogenic agents: osteogenesis refers to the formation of bone, with no indication of cellular origin; the new bone can come from living cells in transplantation or cells derived from the host.

CONCLUSIONS

The osteoconductive materials (porous, tantalum, ceramic, composite calcium phosphate cement) , the osteoinductive factors (Recombinant bone-morphogenetic proteins, demineralized bone matrices) and the bioactive factors (stem cells, platelets) lead to accelerate the healing of bone loss, to prevent an early mobilization of the system, to minimize the complications and to improve the survival of the implant, in the medium and long term.

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