The use of bone substitutes in treating large bone defects after femoral shaft fractures – case report

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Abstract. The femoral shaft fractures are one of the most frequent and serious traumatic disorders encountered in orthopaedic practice. Some of them have large bone defects that complicate the treatment and often result in nonunion. The use of bone substitutes for the treatment of bone defects is an effective and low-risk method. The patient is a 26 years old male, nonsmoker, professional soccer player, victim of a motorvehicle accident (driver) that resulted in politrauma (multiple rib fractures, thoracic contusion, head injury, open complex left femoral shaft fracture Gustilo-Anderson type II, AO type C3, Winquist-Hansen grade IV). The femoral fracture is surgically treated (close reduction and internal fixation using an intramedullary unreamed nail, statically locked). 12 months after the surgical intervention the fracture hasn't healed, and an atrophic nonunion developed. The surgical treatment of the nonunion is performed 13 months after the first surgical intervention. It consists in opening the nonunion site, resecting the bone ends and applying a calcium-phosphate based bone substitute. The postoperative evolution is good and the patient restarts the athletic activity three years after the intervention.
Key words: *femoral shaft fracture, bone defect, bone substitute*.

The femoral shaft fractures are one of the most frequent traumatic disorders. If not correctly treated the femoral shaft fractures are associated with a high rate of complications and functional squeal (1).
Femoral shaft fractures occur in patients of all ages. There is a bimodal pattern age and sex related, these fractures being more frequent in young male patients following high-energy trauma and in elderly female patients after low-energy trauma. High-energy trauma consists in motor vehicle accidents, fall from a height, sport trauma, gunshot wounds and is often associated with multiple lesions.
Associated lesions occur more frequently in young patients as a result of high-energy trauma. The most frequent associated musculoskeletal injuries are: femoral fractures, pelvic ring fractures, patella fractures, tibia fractures, ligamentous injuries of the knee. The ligamentous injuries of the knee, often anterior cruciate ligament injuries, are seldom observed at the time of the initial physical examination (2).
There are multiple treatment methods of the femoral shaft fractures, each of them having its advantages and disadvantages. The choice of treatment depends on type and location of fracture, the comminution grade, the patient's biological status, associated injuries and functional demands. The non-surgical methods of treatment (cast immobilization, skeletal traction) are used only if the surgical treatment is absolutely contraindicated or as a temporary method of immobilization until the definitive surgical treatment.
The surgical treatment is used in the vast majority of cases and it consists in different types of internal fixation (plates, anterograde or retrograde intramedullary nailing) or external fixation. The locked intramedullary internal fixation is considered to be the golden standard in the vast majority of femoral shaft fractures in adults.

The goals of the surgical treatment, disregarding its type, are the restauration of length, axis and rotation of the affected limb, with as few soft tissues injuries as possible, so as the patient's postoperative mobilization and recovery are fast and efficient (3).

The treatment of large bone defects has always been a difficult problem to solve. It is considered that approximately 10% of reconstructive orthopaedic surgery interventions necessitate the use of bone graft or bone substitutes.

The bone defects can be classified by their size and bone extension as follows: limited bone defects –the bone defect is contained inside the bone having intact external borders (cortical bone); uncontained bone defects – the bone defect affects the cortical bone; segmental bone defects – an entire bone segment (trabecular and cortical bone) is missing.

The autologous bone graft is considered to be the golden standard for filling large dimensions bone defects, defects resulting from trauma, tumors, infections or congenital anomalies. The major drawbacks of autologous bone graft harvest are the limited availability and the harvesting site morbidity (pain, infections, arterial and/or venous injuries, nervous lesions, unpleasant cosmetic results). The bone graft consists of trabecular bone, avascular cortical bone, vascularized cortical graft or bone material from the reaming of the medullary canal.

The use of allogenic bone grafts is associated with major risks such as viral diseases transmission (AIDS, hepatitis), tumoral cell transportation, the development of rejection reaction inside the host organism or the production of antibodies through the ABO system if the graft is not ABO compatible.

Because of the disadvantages of the autologous and allogenic bone grafts, the bone substitutes, of either biologic or synthetic origin, are an important alternative to consider.

The most widely used bone substitutes are the calcium phosphate based bone substitutes. These bone substitutes are well tolerated both locally and systemic and have the capacity to fill virtually any bone defect and to be replaced during a variable period of time with bone. The calcium phosphate based bone substitutes have various compositions and are classified in: calcium phosphate based ceramic materials (hydroxiapathite, tricalcic phosphate), calcium phosphate based cement, calcium phosphate based pellets, hydroxiapathite paste with calcium phosphate nanoparticles. Considering the interaction between the bone substitute and the bone, these substitutes are divided in bioactive and bioinert bone substitutes.

This paper presents the case of a 26 years old male, nonsmoker, professional soccer player, victim of a motorvehicle accident (driver). Following the accident the patient was politraumatized (multiple rib fractures, thoracic contusion, head injury, open complex left femoral shaft fracture Gustilo-Anderson type II, AO type C3, Winquist-Hansen grade IV) (4,5) (Fig. 1).

After the patient's hemodynamic stabilization the femoral fracture was emergently surgically treated (wound debridement and lavage using 4 liters of saline solution, close reduction and internal fixation using an intramedullary unreamed nail, statically locked) (Fig. 2). The patient received antithrombotic (enoxaparin) and antibiotic prophylaxis (first generation cephalosporin, aminoglycozide and metronidazolum) (6). Although there is no accepted consensus regarding the risks of intramedullary reaming in patients with thoracic trauma (thoracic contusion, multiple rib fractures) we chose to use an unreamed intramedullary nail in order to reduce the risk of pulmonary embolism if at all possible (7).

At the 12 months after the surgical intervention follow up visit the fracture was not healed, and an atrophic nonunion developed. The surgical treatment of the nonunion is performed 13 months after the first surgical intervention. It consists in opening the nonunion site, resecting the bone ends and applying a calcium-phosphate based bone substitute (Fig. 3).

Three months postoperatively the patient ambulates using a cane, without pain at the fracture site. Radiographically one can observe some degree of lysis of the bone substitute (Fig.4).

One year postoperatively the patient ambulates without any support, full weight bearing. At the fracture site there are bony bridges between the two main fragments, radiographically visible (Fig. 5).

Three years after the application of the bone substitute the patient ambulates full weight bearing, without pain at the fracture site and starts the rehabilitation program in order to resume the athletic activity. The radiographic examination shows a healed fracture, with important bone formation at the fracture site (Fig. 6).

Figure 1. Open femoral shaft fracture following motorvehicle accident (Gustilo-Anderson type II, AO type C3, Winquist-Hansen grade IV)

Figure 2. Internal fixation of the femoral shaft fracture using an intramedullary unreamed nail, statically locked

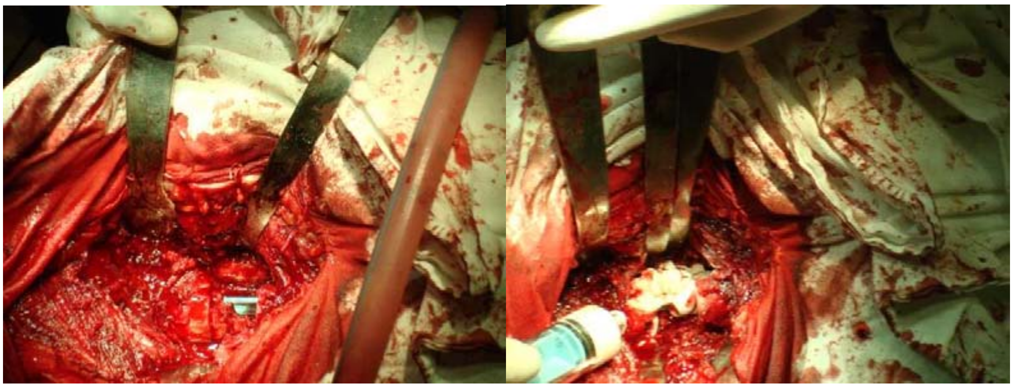

Figure 3. Intraoperative aspects showing the application of the bone substitute

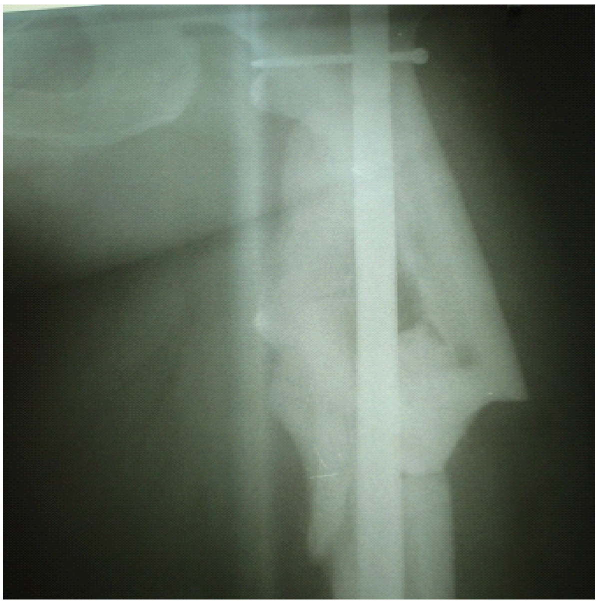

Figure 4. Radiological appearance 3 months after the application of the bone substitute

Figure 5. Radiological appearance one year after the application of the bone substitute showing the formation of bone bridges between the main fragments

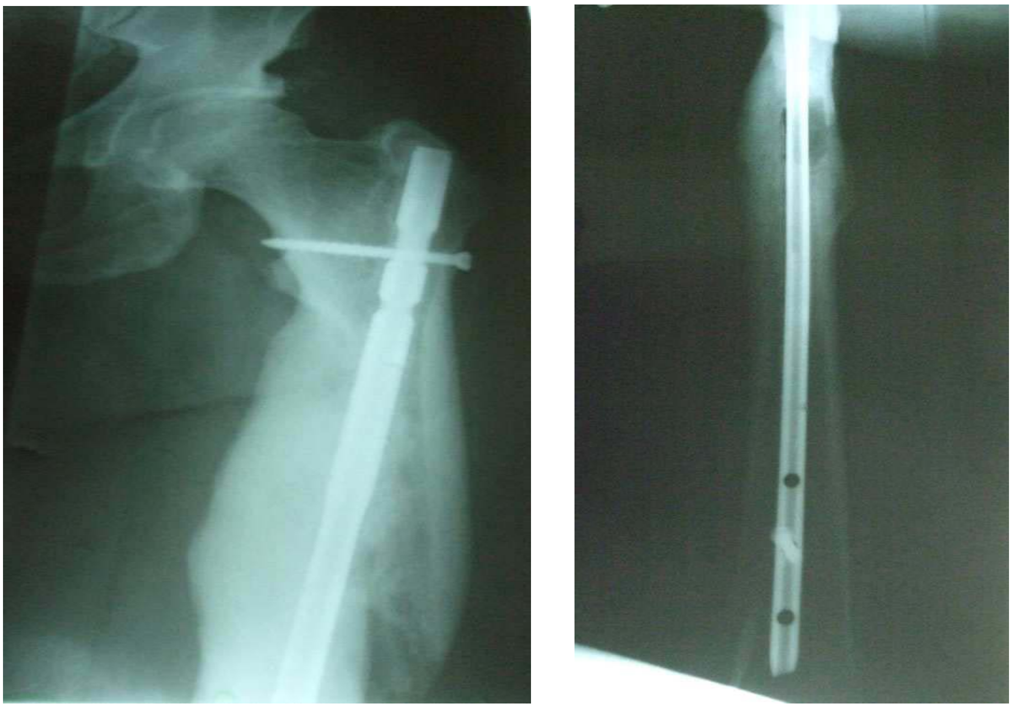

Figure 6. Radiological appearance three years after the application of the bone substitute showing bone formation at the fracture site

Our experience using synthetic bone substitutes is not very vast, but in the last five years we used them in treating bone defects with different localizations (femur, distal radius, calcaneus) with satisfactory results and without important adverse events. That is why we consider that one should consider the use of bone substitutes because of their advantages (no harvesting site morbidity, no risk of disease transmission), their ease in application (some of the bone substitutes can be injected percutaneously) and their good clinical results. However, larger number of patients are necessary in order to formulate some more precise conclusions.

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