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HISTOLOGICAL ASSESSMENT OF NEW BONE FORMATION WITH BIOMIMETIC SCAFFOLD IN THE PRESENCE OF BONE LOSS IN TRAUMA SURGERY

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Purpose : Open reduction and internal fixation (ORIF) surgery may require the use of bone grafts (usually allogeneic). In the context of traumatology surgeries, the use of autologous grafts is almost never used and allogeneic grafts are not always available. In recent years, bone substitutes have been introduced in clinical practice to overcome these limitations.

The purpose of this paper is to report two cases in which the use of a bone substitute was used to overcome the bone loss during surgeries of ORIF.

Two patients, one with a tibial plateau fracture (Schatzker 6) and one with a proximal humerus fracture (Neer 4), underwent ORIF surgery. In both cases, due to a loss of bone stock, a synthetic bone substitute (OrthOss®) was used.

One year after surgery, the complete osseointegration of the synthetic bone substitute was seen, both radiologically and histologically.

This bone substitute may represent a safe and effective alternative to autologous bone grafts, avoiding adverse events related to donor-site morbidity.

Bone graft is the second most common tissue frequently transplanted in the United States and represents a fundamental tool for bone reconstructions in trauma surgery where an important loss of bone stock occurs (1) (2) (3).

The qualitatively ideal graft is undoubtedly the autologous tissue, but it certainly exposes to the comorbidities of the donor site and has the limiting factor related to the amount of tissue needed as large quantities of tissue cannot be removed (4)(5). Allogeneic grafts, on the other hand, are not always available (6). For these reasons, the use of synthetic bone substitutes has been increasing in recent years (7) (8). These have the advantage of being always available and of being indicated even in large quantities.

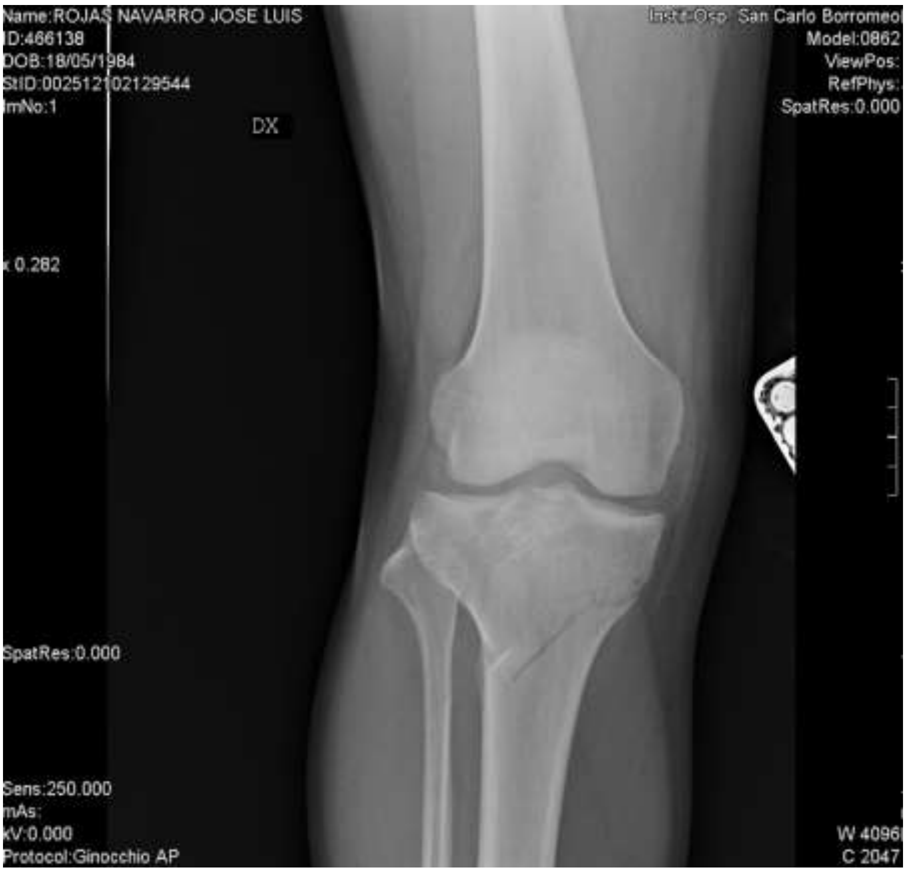
The objective of this paper was the analysis of the clinical outcome and the quality of the newly formed bone tissue in two patients, presenting a fracture of the tibial plateau and a fracture of the head of the humerus, respectively, where a synthetic bone substitute was used to treat major bone loss.

Open reduction and internal fixation of tibial plateau fracture

A 28-year-old male patient arrived to the emergency room following a high-energy motorcycle accident conditioning direct trauma to the knee and right leg. A tibial plateau fracture was diagnosed (type 6 according to Schatzker classification) (**Fig. 1 A and B**).

The ORIF surgery was then performed using an angular stability plate and screws. An important loss of bone substance was found intraoperatively and a synthetic graft (OrthOss®) was used (**Fig. 2 A and B**).

Serial radiographs over time showed progressive fracture healing with good osseointegration of the synthetic bone substitute; the plaque removal was performed after 14 months from the first surgery.

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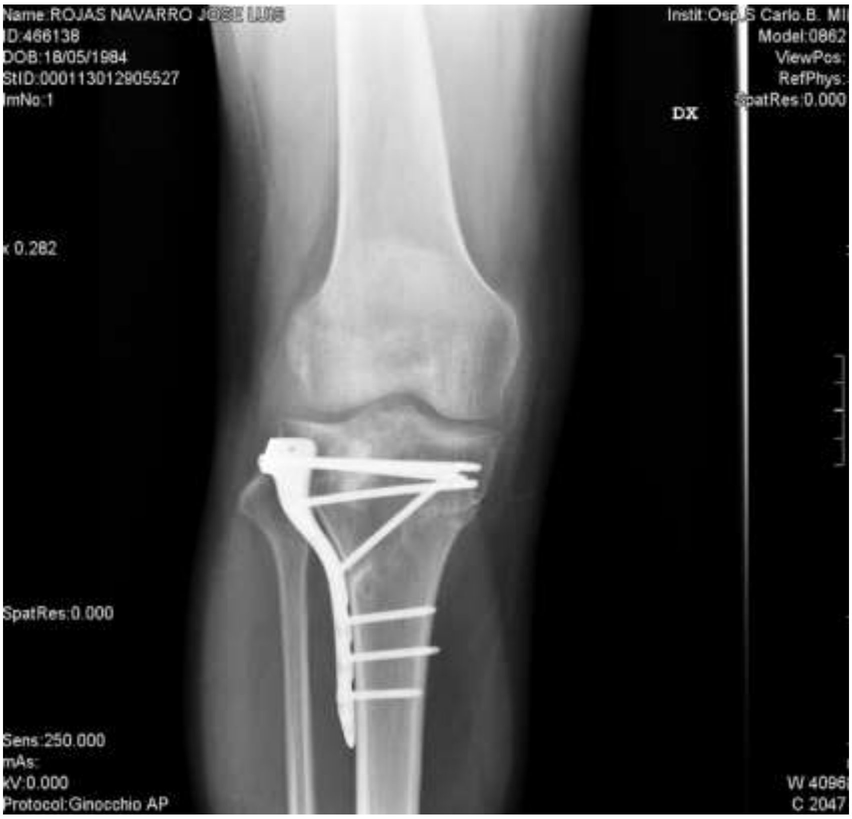
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Open reduction and internal fixation of proximal humerus fracture

A 56-year-old female patient arrived to the Emergency Room after a fall from a ladder, leading to direct trauma to the left shoulder.

A proximal humerus fracture (fourth type according to Neer) associated with anterior glenohumeral dislocation was diagnosed (**Fig. 3**)

Three days after the trauma, under general anesthesia, an open reduction and internal fixation and reduction of the dislocation surgery was performed. (**Fig. 4**)

Also in this case, the same synthetic bone substitute was used.

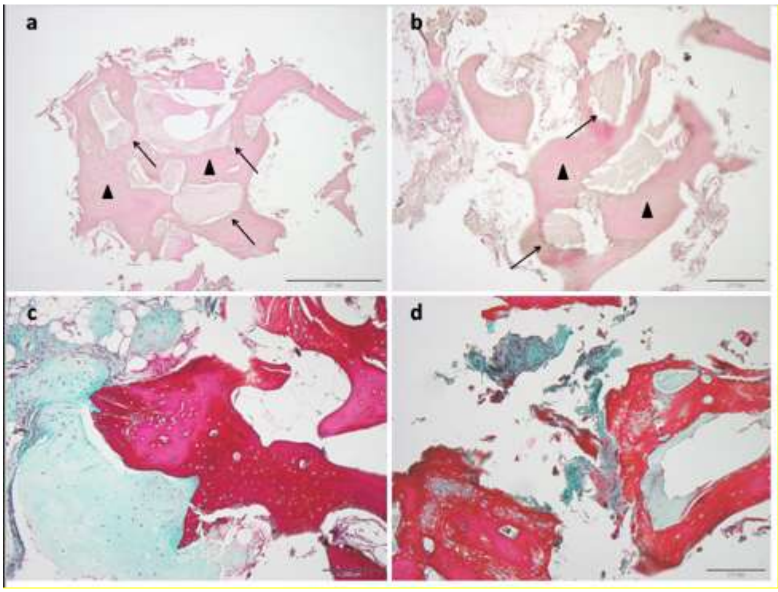
Serial radiographs showed good bone consolidation and plaque removal was performed after 16 months from the first surgery.

MATERIALS AND METHODS

Formalin-fixed samples were decalcified in a formic acid-sodium citrate solution. After decalcification procedure, samples were rinsed for 10 min in running water and processed for paraffin embedding through a graded ethanol series. Four micrometer-thick sections were obtained and stained with hematoxylin/eosin and Masson's trichrome staining protocols and observed with an Olympus BX51 microscope (Olympus, Italy).

RESULTS

The histological study revealed that the scaffold was not degraded after 60 weeks of implantation and it was still present in the defect area (**Fig. 5** a-shoulder, b-tibia, arrows). In both cases, the first observation was the presence of newly formed bone: actually, new tissue was only observed around the scaffold particles (Figure 5 a-shoulder, b-tibia, arrowheads). The Masson's trichrome staining allowed better contrast between newly formed tissues as compared to hematoxylin/eosin stains. Interestingly, the presence of chondral zones (**Fig. 5** c-shoulder, d-tibia in green color) adjacent to woven bone revealed that endochondral ossification – typically observed in naturally-occurring bone healing processes (**Fig. 5** c-shoulder, d-tibia in red color).



CONCLUSION

In recent years, thanks to technological developments, the number of synthetic bone substitutes to be used as a graft in case of loss of bone substance or nonunion has increased. On the other hand, having such a broad spectrum of therapeutic or surgical options can be confusing for the surgeon who is facing with this type of operations.

Most of the studies in the literature that deal with bone grafts (autologous, allogeneic or synthetic) are of low statistical level or are case series. There are no randomized controlled trials comparing these three types of grafting. These studies would serve to create diagnostic and therapeutic protocols that can form action algorithms. Until these studies are done, the choice of the best bone graft remains based on personal experience, the type of patient and the type of fracture.

The synthetic bone substitute Orthoss® utilized here is manufactured from natural bovine bone, it is a xenogeneic inorganic bone matrix (containing no living cells) and a natural nanocrystalline carbonated hydroxyapatite: Ca10(PO4)6(OH)2 and does not contain any soft tissue or organic material. It demonstrated good osteoconductive and biotolerance abilities and may be used in case of large bone losses in the context of trauma surgery.

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Conflict of interest: None of the authors has any conflict of interest related to the subject of the present work.

Figure legends

Fig. 1 *Pre-operative Rx ray of tibial plateau fracture of the right knee, Anterior-Posterior view (A) and lateral view (B)*

Fig. 2 *Post-operative Rx ray, Anterior-Posterior view (A) and lateral view (B)*

Fig. 3 *Pre-operative Rx ray of humerus fracture*

Fig. 4 *Post-operative Rx ray of humerus fracture*

Fig. 5 Histological samples, a,c: shoulder, b,d: tibia; a,b: hematoxylin/eosin, c,d: Masson's trichrome staining. Newly formed bone (arrows) is visible around the scaffold

particles (arrowheads). The chondral zones (green color in c and d) is located close to the woven bone (endochondral ossification: red color in c and d).
Scale bar 200μm