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REVIEW /*Interventional imaging*

Augmented osteoplasty for proximal femur consolidation in cancer patients: Biomechanical considerations and techniques

F.H. Cornelis[a,*], **F. Deschamps**[b]

[a] *Department of Radiology, Hôpital Tenon, 4, rue de la Chine, 75020 Paris, France*
[b] *Department of Interventional Radiology, Gustave-Roussy cancer center, 114, rue Edouard-Vaillant, 94805 Villejuif, France*

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Abstract According to the literature, prophylactic consolidation of lytic metastasis located in the proximal femur is recommended when the Mirels' score is above 8. Osteoplasty alone provides inadequate consolidation but various devices have been used in association for better consolidation. The aim of this review is to detail the augmented osteoplasty techniques published in the literature and to report their safeties and their efficacies to prevent pathological fracture of the proximal femur. A Pubmed research found 5 studies that evaluated augmented osteoplasty of the proximal femur in cancer patients. All devices demonstrate adequate safety and low rate of secondary pathological fractures.

Current advances in oncology have improved the mean overall survival of patients with metastatic bone disease [1]. Bone metastases are frequently localized at the trochanteric region and femoral neck, predisposing to pathological fractures [2]. These fractures may have serious consequences to the patients' quality of life but also to their overall survival [3].

* Corresponding author.
E-mail address: cornelisfrancois@gmail.com (F.H. Cornelis).

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According to the literature, prophylactic consolidation is recommended in cases of lytic metastases of the proximal femur presenting a Mirels' score ≥ 8 [4–6] (Table 1). While this weighted scoring system was proposed to quantify the risk of sustaining a pathologic fracture through any metastatic lesion in a long bone, the decision to perform surgical consolidation may also take into consideration the patient's performance status and life expectancy. As surgery can have significant morbidity in cancer patients, minimally invasive treatment options may be considered in this fragile population [7].

Percutaneous osteoplasty has proved to be highly effective for the palliation of pain from bone metastases alone or in combination of other techniques such as ablation [8–11]. However, it was argued so far that it should be contraindicated for metastases that are located in the proximal femur because of inadequate bone consolidation during weight bearing [8,12–14]. Thus the rate of fractures despites osteoplasty is very high in the literature. In a retrospective analysis of 21 consecutives patients, fractures occurred in one third of the patients and was significantly more frequent if a > 30 mm cortical rupture is associated [8,12–14]. In addition, revision surgery of proximal femur fracture that occurs despites osteoplasty is consider to be a challenging procedure [15]. To improve mechanical consolidation of osteoplasty, several authors have proposed to associate osteoplasty with the insertion of different type of devices in the femur [16–21]. These procedures are defined as augmented osteoplasties. The aim of this review was to detail the techniques of augmented osteoplasty proposed, thus far in the literature and to report the early results in terms of safety and efficacy.

Evidence acquisition

A systematic MEDLINE/PubMed© literature search was performed with different combinations of terms as ''hip'', ''femoral neck'', ''osteoplasty'', ''co'', ''tumor''. Time period included articles published between January 2000 and February 2017. Original articles, reviews and editorials were selected based on their clinical relevance. Cited references from selected articles were analyzed to find and include significant papers previously excluded from our search, including articles published before 2000.

Biomechanical considerations for osteoplasty of the proximal femur

As bone cement (polymethyl methacrylate, PMMA) demonstrates biomechanical properties that are weak in tension but strong in compression, its benefit for vertebral body consolidation is appropriate. However, osteoplasty is ineffective in proximal femur because of the multiple stresses applied in this location during weight bearing [22,23]. This is the reason why several authors believe that an intramedullary instrumentation is necessary for sufficient long-term consolidation of the proximal femur where rotational and shearing forces are applied [7]. The combination of cement and orthopedic devices has demonstrated a significant improvement in mechanical consolidation in the proximal femur [24]. Thus, the augmented osteoplasty may overcome therefore the limitations of osteoplasty alone reported so far.

Two concepts may be applied for augmented osteoplasty of the proximal femur as recommended in surgery (Table 2) [25]. Firstly, consolidation may only involve the femoral neck (Fig. 1). Less invasive, this technique should be considered only for small lesion as consolidation covers only a limited area of the bone. Secondly, in case of larger lesion, it may be interesting to further lock the material using an intramedullary anchorage for instance. Although more complex to achieve, this concept allows better stabilization. However, both require solid bone around the lesion as well as the use of cement for secure fixation of the devices.

Techniques of augmented osteoplasty

Wires and cannulated screws

Percutaneous consolidation of impending pathological fracture of the proximal femur using osteoplasty and pins (such as Kirschner wire) or cannulated screws appeared feasible even under conscious sedation and imaging guidance [16,18,26]. Each devices (pin or screw) must enter a strong cortical bone, at best in three places following the ''three point principle'', to provide maximum resistance to rotation [27]. The devices inserted distally prevent varus angulation and the proximal devices prevent dorsal angulation of the femoral head [16]. However the configuration has to be adapted to the location and size of the tumor to ensure sufficient anchoring of the devices in healthy bone.

Table 1 Mirel's scoring system [4].

Score	1	2	3
Pain (Visual Analog Scale)	≤ 4	5–7	≥ 8
Nature of the lesion	Blastic	Mixed	Lytic
Size of the lesion	< 1/3 of cortex	1/3 to 2/3 of cortex	> 2/3 of cortex
Site of the lesion	Upper limb	Lower limb	Trochanteric region

A score of 1 to 3 is given for four criteria and summed together. A score greater than 8 suggests prophylactic internal consolidation prior to irradiation.

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