A surgical procedure to deliver a triphasic calcium-based implant material to address local bone loss and strengthen an osteoporotic proximal femur: a case report

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ABSTRACT

Bone loss associated with the systemic skeletal disease osteoporosis results in weakened or fragile bone, the most serious consequence of which is fracture. A 67-year-old post-menopausal Caucasian woman presented with a diagnosis of osteoporosis by FRAX and DXA and a history of a fragility hip fracture. The patient was classified according to the latest guidance document for treating patients with post-menopausal osteoporosis from the International Osteoporosis Foundation and European Society for Clinical and Economic Aspects of Osteoporosis. The patient was at very high risk for major osteoporotic fracture, including hip fracture. This case report describes the use of a minimally invasive surgical procedure to address bone loss in the proximal femur associated with osteoporosis. Local osteo-enhancement procedure (LOEP), a minimally invasive surgical procedure, was performed using a triphasic calcium-based implant material, AGN1. LOEP was carried out under general anesthesia and fluoroscopic navigation. The area of bone loss in the proximal femur, the enhancement site, was identified, debrided, and irrigated to prepare it for low-pressure filling with AGN1 implant material. The patient recovered from the procedure without incident and was discharged without activity limitations after an overnight stay. X-ray imaging and DXA scans were used to evaluate implant material resorption and replacement with bone over a 3.25-year follow up. A significant and sustained increase in femoral neck and total hip BMD was observed (pre vs 3.25 years post-procedure: 0.546 *vs* 1.031 gm/cm^2 and 0.628 vs 0.96 gm/cm^2, respectively), which corresponded to a change in the patient's T-score from the osteoporosis range to normal. Based on the use of T-scores to measure the risk of fragility fractures, and acknowledging the well-published limitations of doing so, the hip fracture risk of this patient was reduced from very high to low. This case report documents the use of this minimally invasive, targeted procedure to address hip fragility fracture (the most serious issue in the systemic disease osteoporosis), with AGN1 implant material used to replace bone lost in the proximal femur.

KEYWORDS

Strengthening, osteoporosis, local osteo-enhancement procedure, LOEP, fracture risk, DXA, fragility fracture, bone loss.

Introduction

The systemic skeletal disease osteoporosis results in bone loss and deterioration of the microarchitecture of bone, decreasing bone strength and significantly increasing the risk of a fragility fracture. Fragility fractures are the most prevalent and serious clinical consequence of weakened, fragile bone [1]. Fragility fractures of the hip are the most consequential fractures, resulting in significant mortality and morbidity [2,3]. It is estimated that globally, hip fragility fractures will affect 4.5 to 6.3 million women per year by 2050 [4]. Recently, fragility fractures have been increasing as a result of an aging population and a decreasing trend in osteoporosis diagnosis and use of osteoporotic medications. Although systemic pharmacological therapies are important, they remain an incomplete solution in the overall treatment to prevent fragility fractures, due both to the prolonged time needed to achieve protection, and to low compliance and persistence. Ultimately, they reduce hip fractures by only 50% at best. Consequently, there is a significant treatment gap in osteoporosis patients resulting in a call in both the scientific literature and the lay press for new approaches to prevent fragility fractures [5]. One such approach worth considering is local osteo-enhancement, a procedural technique that prior research has shown to immediately and durably increase the strength of the proximal femur, thereby directly addressing local osteoporotic bone loss [6-9].

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Case report

This report concerns a 67-year-old post-menopausal Caucasian woman who presented with a prior history of a hip fragility fracture. Her medications included alendronate and vitamin D3. She also had a positive history for smoking and alcohol use. Her height was 1.71 meters and she weighed 65 kg, for a BMI of 22.2. Screening X-rays showed normal hip anatomy with a well-maintained joint space and evidence of decreased bone density and microarchitecture in the proximal femur.

FRAX evaluation showed a 25% ten-year probability of a major osteoporotic fracture and a 13% 10-year probability of a hip fracture. Both scores are above the Bone Health and Osteoporosis Foundation's (formerly National Osteoporosis Foundation's [USA]) suggested thresholds for intervention (i.e., 20% and 3%, respectively) [10].

The patient's DXA scan T-score of -2.6 at the femoral neck and -2.6 at the total hip were both in the osteoporosis range according to the World Health Organization definition [8]. Multiple recent publications have focused on fracture risk in osteoporotic patients and their appropriate treatment [5,7,8]. The International Osteoporosis Foundation (IOF) and the European Society for Clinical and Economic Aspects of Osteoporosis (ESCEO) have published guidance documents that have been proposed as a platform to help individual countries establish guidelines for diagnosis and treatment [6-8]. This patient's FRAX score and DXA evaluation, combined with her positive history of hip fracture, indicated that she was at very high or even possibly imminent risk for a contralateral hip fracture as defined by European guidance [6-8], and so the local osteo-enhancement procedure (LOEP) was performed.

In November 2017, after a discussion of the risks and benefits, and completion of a medical work-up and consent, the patient underwent surgical treatment of her left hip with LOEP involving implantation of a triphasic calcium-based implant material (AGN1) (the surgical kit used in this case has a CE-mark and was manufactured by AgNovos Healthcare, Rockville, MD USA).

The case was performed under general and local anesthesia. A 1-cm skin incision in the lateral thigh was made to access the lateral femoral cortex just below the greater trochanter at the level of the proximal extent of the lesser trochanter. Under fluoroscopic guidance, a 2.5-mm guide pin was placed through the center of the femoral neck (Fig. 1A) and a 5.3-mm cannulated drill was advanced over the guide pin to the subcapital femoral epiphyseal scar (Fig. 1B). The proximal femur was gently probed and debrided followed by suction/irrigation to remove fat and other non-structural material (Fig. 1C). The AGN1 implant material was then mixed and injected starting at the apex of the enhancement site. Under fluoroscopic guidance, the injection progressed distally filling the site to the lateral femoral entry portal (Fig. 1D). The skin-to-skin time was 22 minutes and 20 cc of AGN1 was injected. The patient's recovery was uneventful, and she was discharged from the hospital the next day. No physical therapy or limitations on weight bearing were recommended. There were no implant or procedural complications, and the patient returned to full activity several days after the surgery. The post-procedure AP film (Fig. 2A) at 4 months shows implant material resorption and new bone formation. The AP film (Fig. 2B) at 3.25 years shows complete implant material resorption and replacement with bone in the enhancement site. The DXA T-scores at 3.25 years post-procedure vs. pre-treatment were: -0.1 (1.031 gm/cm^2) vs. -2.6 (0.546) for the femoral neck and -0.4 (0.96 gm/cm^2) vs. -2.6 (0.628) for the total hip.

Discussion

The goal of systemic treatment of osteoporosis is to reduce fragility fracture risk by reducing bone loss and/or encouraging bone formation, as it is the loss of bone and deterioration of bone microarchitecture that results in weakened bones that are less able to withstand the forces generated in a fall, potentially resulting in a fragility fracture.

While new pharmaceutical treatments have been introduced, they are not a complete solution and unmet needs in osteoporosis care have persisted [5]. As a result, many investigators have studied alternative ways to address bone fragility by strengthening areas of the skeleton that fail under stress and result in the most significant morbidity and mortality. Various constructs to strengthen the proximal femur have been tested in cadaver studies and in limited clinical studies. Polymethyl methacrylate has been the most frequently used material for augmentation, either alone or in combination with other materials. Other strategies have included the use of metal fixa-

Figure 1 Simulated fluoroscopy images outlining selected steps in the procedural technique for LOEP: 2.5-mm guide pin placed through the center of the femoral neck (A); 5.3-mm canulated drill advanced over the guide pin to the subcapital femoral epiphyseal scar (B); proximal femur gently probed, debrided, suctioned and irrigated to remove fat and other non-structural material (C); injection at the enhancement site proceeding distally from the apex to the lateral femoral entry portal (D).

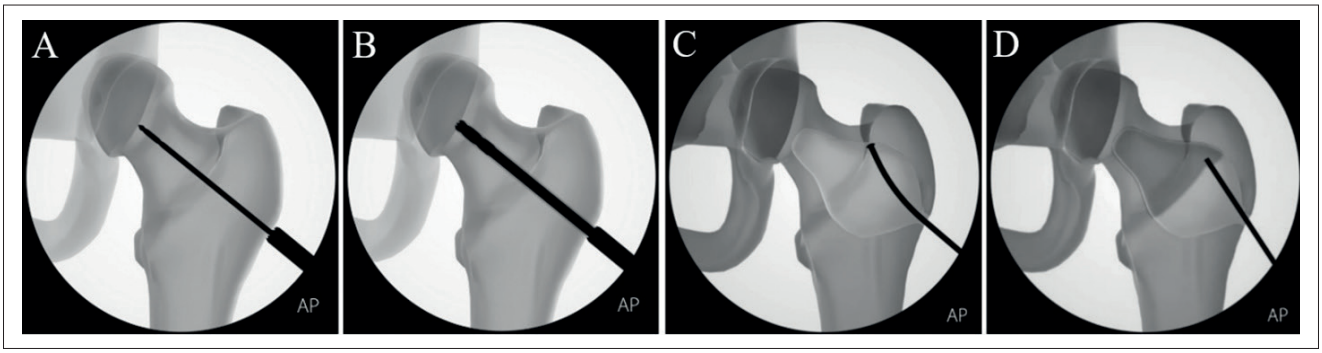
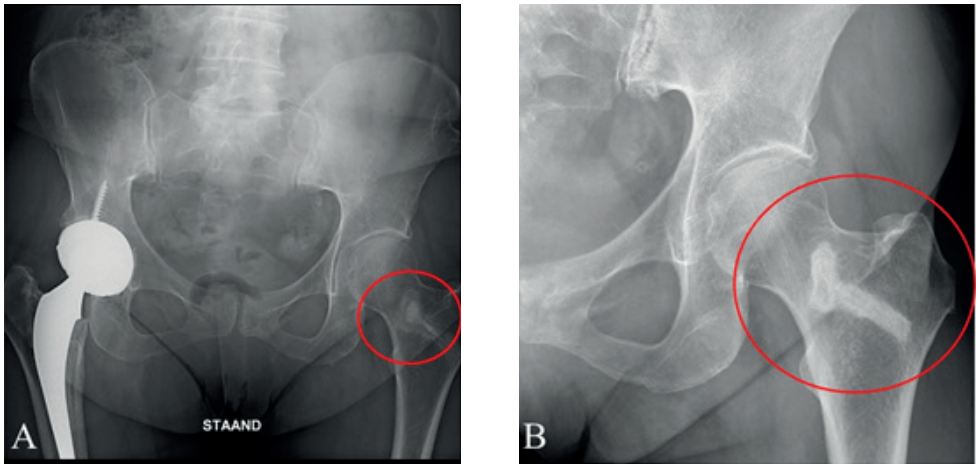


Figure 2 Post-procedure AP films showing implant material resorption and new bone formation at 4 months (A) and complete implant material resorption and replacement with bone at 3.25 years (B).



tion, carbon sleeves and bioactive screws [9]. Although these approaches result in some degree of increased proximal femur strength, they are relatively invasive and have had limited clinical success. They also leave in place permanent implants with mechanical properties that are inconsistent with bone, raising the possibility of unintended biomechanical outcomes such as stress shielding and the formation of stress risers.

LOEP differs from approaches that use inert, permanent implants since it utilizes a regenerative implant material that has been shown in pre-clinical, cadaver, and clinical studies to immediately strengthen treated hips, and to be resorbed and replaced by bone, resulting in a durable increase in strength [9,11,12]. Because implant material resorption is coupled with new bone formation, there is no dissociation between resorption and bone formation. Since the implant material is fully resorbed and replaced by new bone, there is no reason to expect any mismatch in the material properties of new and host bone.

Conclusion

This case report documents the treatment of a post-menopausal women with osteoporosis and very high hip fracture risk using LOEP. The procedure was well tolerated, required no special rehabilitation, and allowed the patient to rapidly return to activities of daily living. The AGN1 implant material resorbed and was replaced by bone. The improvement in proximal femur areal bone mineral density (aBMD) was substantial and durable. Prior to treatment, the patient was categorized based on IOF/ESCEO guidance to be at very high risk of major osteoporotic fracture, including hip fracture [6]. Following treatment with LOEP, the patient's femoral neck and total hip T-scores were in the normal range, suggesting a reduction in hip fracture risk. This case study is one example of AGN1 local osteo-enhancement treatment resulting in new bone formation in the proximal femur of a patient at very high or possibly imminent fracture risk [7,8]. Further use according to labeling and additional clinical research in similar patients and other populations is warranted.

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