Original article

Short femoral stem and porous titanium: winning combination?

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Abstract. A lot of different implants are available in hip replacement arthroplasty (THA), stems differ mainly by type of fixation, material, length, diameter, shape, surface coating, modularity, etc. The main quality of a non-cemented stem is to pursuit primary and secondary stability, to preserve bone stock, to be adaptable and modular. The literature shows that the most popular non cemented stems used in THA are metaphyseal femoral stem in which the distal portion has only the action to avoid varus stem placement but can also be a source of complications such as stress shielding. The stability of a short stem is closely dependent on material that must allow a high "scratch fit" and facilitate osteointegration with a generous surface of bone-implant contact. From September 2010 we have performed 287 THA using a modular porous titanium short stem. The article shows the preliminary results, which are very encouraging, showing excellent primary and secondary osteointegration, also in slightly undersized implants or in elderly porotic patients. (www.actabiomedica.it)

Key words: porous titanium, short stem, bone stock

Introduction

Hip replacement surgery involves lot of different types of stems with 10,000 combinations of implants that differs for type of fixation, material, length, diameter, shape, surface coating, etc. ... The whole lot always seeking the highest primary and secondary stability and bone stock preservation.

The need for a short-stem comes from the desire of a "real" minimally invasive surgery, not only cutaneous but also bony. This is especially true in young patients in order to ensure the maximum chance of saving bone tissue for possible future revision.

Everything started by the evidence of how the most widespread cementless stems have a metaphyseal biomechanically active grip; the distal portion has practically a centering function to avoid varus placement. The distal portion can often be a source of complications if it engages too deep in the medullary canal leading to a distal stabilization and as a result in time proximal stress shielding, leading to bone resorption in Gruen zones 1 and 7.

The short stem, instead, transmits a more physiological load in the metaphyseal area (1) with consequent maximum preservation of bone stock and absence of stress shielding but the lack of the distal portion can give stability problems with secondary varus deviations. The stability of a short stem is directly dependent on the geometrical characteristics of the stem itself that must have the maximum grip at metaphyseal level and also by the characteristics of the contact surface with the bone, which should enable an initial high "scratch fit" and facilitate osteointegration. This can be achieved with a bone-implant contact surface area as wide as possible.

The stem we used presents modular necks and uses the construction technique of "porous titanium." This extremely innovative technique isn't a surface treatment but consists of a three-dimensional surface constructed in one piece with the body of the stem, starting from titanium powder (2). This allows, in contrast with other processes, to avoid delamination.

The surface porosity of 700 microns provides excellent primary stability and a faster direct osteointegration without interposition of fibrous tissue.

This has been widely demonstrated by the study of Prof. Giardino at Rizzoli Orthopaedic Institute with the implantation of TiPore titanium cylinders in the trabecular bone of the distal femur of animals and highlighting the growth of cancellous bone in reparative phase with thin and dense trabeculae penetrating into the spaces created by the superficial macroporosity, already at two postoperative weeks .

The porous titanium is biocompatible as demonstrated by in vitro studies where stem cells grow and multiply on the prosthesis stem much greater than in stems with different surface treatments (3, 4).

The stem has the characteristic to search only the metaphyseal stability, saving substantially the bone stock compared to traditional stems. The primary stability is highly dependent on the characteristics of porous titanium. Titanium has been used in orthopaedic surgery for more than 35 years, and in 1981 was described the phenomenon of '"osteointegration" as the formation of lamellar bone without the interposition of fibrous tissue around the implants (5). The porous titanium stands out for its three-dimensional structure that mimics the morphology of human bone, creating an ideal space for bone ingrowth (6). The surface roughness allows to obtain a high initial scratch-fit while the porosity of the surface determines a marked increase of the bone-implant contact surface area.

The high porosity is allowed by interconnected pores of 700 microns and 40 microns of additional spikes at the junction (Ti-por) (Fig. 1). An optimal diameter of the pores plays an important role in the colonization process and improves the quality of the bone tissue surrounding the implant (7). In the presence of pores with a diameter smaller than 300 microns osteointegration occurs through indirect osteogenesis while if the diameter exceeds 300 microns there is an improvement of the local microcirculation with more oxygenated bone, that integrates in direct osteogenesis (8).

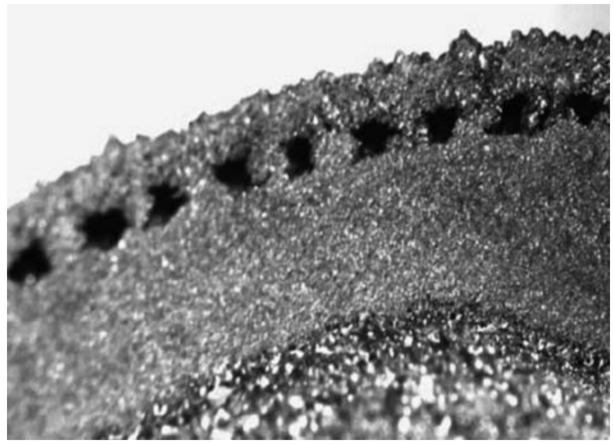

Figure 1. Porous titanium

The short stem is adaptable to various types of metaphysis with maximum trochanteric and calcar area bone stock respect: the possibility of implanting modular necks covering 27 positions of the space make it ideal for situations such as coxa vara and valga, neck deformities where it can be difficult to find the optimal offset with monoblock stems.

The modular necks system provides three offset possibilities that combine with three lengths and three versions, leaving the possibility of correcting each parameter independently from the other.

Materials and methods

For two years we have created a group of first-users of the stem called "Vitae".

Our group is led by Prof. Lisanti, Director of the Orthopaedic Clinic of the University of Pisa, which includes us, Dr. M. Olivieri of Genoa and Dr. U Fusco of Busto Arsizio.

We implanted from September 2010 to March 2012 n. 287 stems. The study sample includes male and female patients, who underwent surgery for hip replacement for primary and secondary coxarthrosis, aged between 39 and 75 years. This group also includes patients with coxa vara, coxa valga and neck deformities. We have so far restricted the indication to patients weighing less than 90 kg and not particularly osteoporotic bone. The study protocol includes clinical revaluations at 1-3-6-12-18 months after surgery; after the follow-up provides annual inspections. All the controls includes radiographic evaluation.

The evaluation criteria include the identification of pain (VAS) and the changes in Harris Hip Score.

Results

To date in 287 cases treated we have had four ntraoperative calcar fissures and five cases of varus stem placement more than two mm (Fig. 2). No revision has been carried out so far and our impressions on clinical outcomes are extremely valid. Obviously, given the limited follow-up, we still should not discuss the final results.

We have always found that the varus stem placement, found at the postoperative check up after one month, never caused any pain to the patient and has always stabilized without further changes at subsequent radiographic controls.

In the presence of good bone quality we wanted stability with the stem that "floats" on compressed cancellous bone resulting in a real bone saving with optimal unloading of the forces on the metaphysis and respect for the trochanteric bone stock (Fig. 3). In the presence, on the contrary of osteoporotic bone, osteointegration is still guaranteed, but only with a stem "mold" and with cortical support (Fig. 4).

Figure 2. Comparison between postoperative control end one month control: varus deviation of the stem

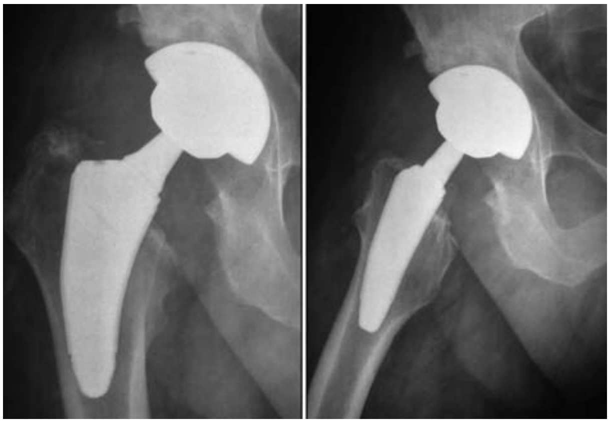

Figure 3. "Floating" stem in cancellous bone, 6 month control

Figure 4. "Mold stem", 12 month control

Discussion and conclusions

Preliminary results have always shown very encouraging and excellent osteointegration, even in slightly undersized implants or in elderly porotic patients. The limit found in these subjects and in obese patients is related to the implant biomechanic; the shorter the stem is the greater the load force at the interface between the stem and bone so if the lever arm exceeds the capacity of the stem to anchor the bone, can deflect in varus (9).

The design offers high resistance to twisting and sinking, the reduced trochanteric shoulder contributes to the high-saving bone side. The load in the metaphyseal area is physiological without possibility of proximal stress shielding while the fit is achieved irrespective of the size of the channel allowing the use even in femurs with neck deformity or narrow channels.

The short stem is, finally, in our experience, suitable for any surgical approach.

The considerations set out above allow us, for now, to sustain that the porous titanium can be a winning combination especially for a short stem allowing a widespread use with confidence. Obviously it will be necessary to reevaluate the case study with a follow-up in the medium to long term.

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