MENTORS IN ORTHOPEDICS

CALCAR-GUIDED SHORT STEMS - THERE'S NO GETTING AROUND IN MODERN THA

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SUMMARY

Background: Total hip arthroplasty (THA) is increasingly performed in younger, active patient populations who require optimized postoperative function. While conventional stems provide reliable long-term outcomes, the demand for bone-conserving and soft-tissue-sparing techniques has led to the development of various short-stem femoral implants.

Objective: This review evaluates the classification, surgical philosophy, and clinical performance of calcar-guided short stems, focusing on their role in anatomical reconstruction and minimally invasive surgery (MIS).

Key Points: Short stems are classified by the level of femoral neck resection: neck-retaining, partially neck-retaining (calcar-guided), and neck-resecting. Calcar-guided designs represent the current generation, utilizing an individualized resection level to facilitate anatomical reconstruction of the femoro-acetabular offset and center-collum-diaphysis (CCD) angle. These implants support "round-the-corner" insertion, which preserves the greater trochanter and abductor musculature. Primary stability is achieved through metaphyseal anchoring; however, surgeons must avoid undersizing in valgus femoral morphologies to prevent implant subsidence. National registry data indicate that specific calcar-guided models demonstrate one-year revision rates between 0.3% and 0.8%, which are comparable to or lower than those of conventional straight stems (1.5%).

Conclusion: Calcar-guided short stems facilitate precise anatomical restoration and soft-tissue preservation through individualized positioning. Although long-term data are still emerging, current registry evidence supports their efficacy as a viable alternative to conventional designs in modern THA, particularly when combined with minimally invasive approaches and appropriate intraoperative imaging to ensure stable metaphyseal fixation.

KEYWORDS

Arthroplasty, Replacement, Hip; Hip Prosthesis; Femur; Minimally Invasive Surgical Procedures; Prosthesis Design

WHAT'S NEW IN THA?

Total hip arthroplasty (THA) is one of the most successful procedures of the last century providing excellent long-term results [1]. However, worldwide increasingly young and active patients with osteoarthritis are treated with THA, thus being more demanding regarding postoperative clinical function and physical activity. In Europe already over 20% of all patients treated with THA are under the age of 60 years [2].

The request for surgical procedures and implants allowing an active, high quality daily life is constantly advancing. Consequently minimally-invasive techniques have been developed, allowing a muscle- and soft-tissue sparing implantation. In modern THA, however, not only the choice of approach determines the postoperative outcome, but also the type of implant. Choosing the adequate stem highly contributes to being able to optimally use minimally-invasive techniques [3],[4] (Figure 1).

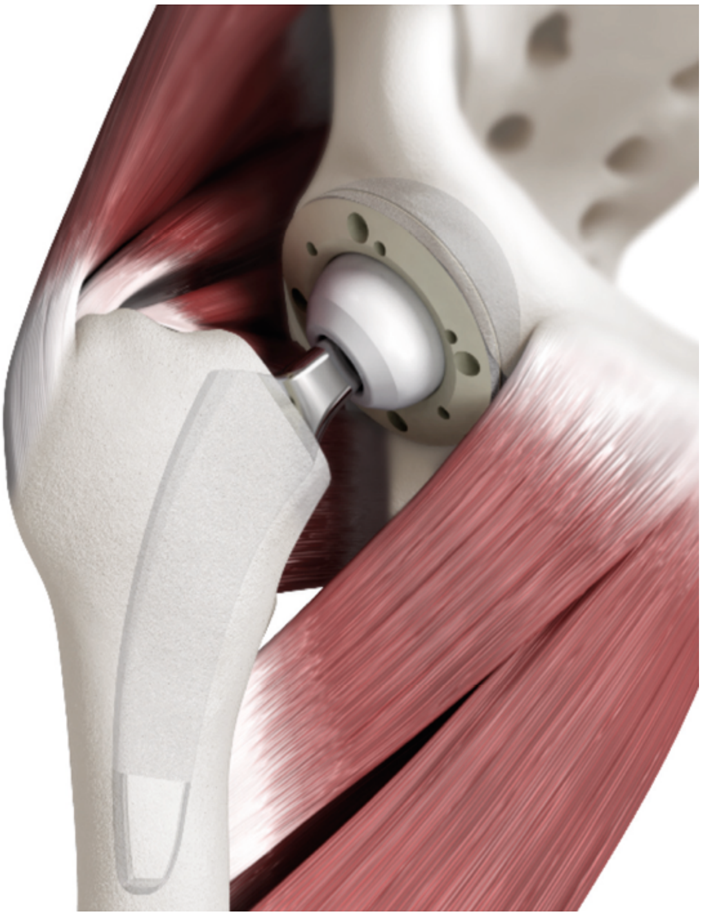

Figure 1: Bone- and soft-tissue sparing calcar-guided short stem.

SHORT-STEM THA: DOES LENGTH MATTER?

Short-stems have already been developed decades ago, in order to ensure a bone- and soft-tissue sparing implantation. Since already the first short femoral implants like the Mayo-stem (Zimmer) and the C.F.P.-stem

(Link) provided encouraging mid-term results, in recent years numerous innovations and modifications emerged to the market. However, at the same time, some short-stem designs have already been withdrawn from the market due to different reasons. The concept of short-stem THA especially in Europe since then has become increasingly important and implantation figures constantly go up year by year. However, there is a large variety of different models of short-stems, differing in design and function [5].

CLASSIFICATION OF SHORT STEMS

Because of the heterogeneity of different short-stem designs, a universally applicable classification seems necessary [5],[6]

One expedient classification has been proposed by Jerosch in 2012 [7] and has been adjusted by Falez et. al in 2015 [5]. It uses the corresponding level of resection of the femoral neck. It differentiates neck retaining, partially neck retaining and neck resecting short stems. This takes into account distinctions in terms of biomechanics and implantation techniques [8].

Neck retaining implants best allow sparing of bone (Figure 2a). However, also a
superior quality of bone for this kind of implants is essential. The reconstruction of individual anatomy and biomechanics is very limited. Due to high revision rates, these stems did not prove to be reliable and mostly have been withdrawn from the marked (Cut, ESKA Implants; Silent, Depuy-Synthes) [9].

Neck resecting short stems largely correspond to the philosophy of past conventional straight stems and require similar quality of bone (Figure 2b). In order to reconstruct hip geometry in terms of offset and leg length, a high amount of modularity and different sizes is needed and often accuracy is poor [10].

The Mayo-stem (Zimmer) is the one providing most long-term results but has been already been withdrawn from the marked due to the advancing progress. A similar
implant, the Metha-stem (Aesculap) started off with problems regarding fretting and corrosion of the modular necks [11]. The monoblock version, providing different predefined CCD-angles, still is broadly used today [12].

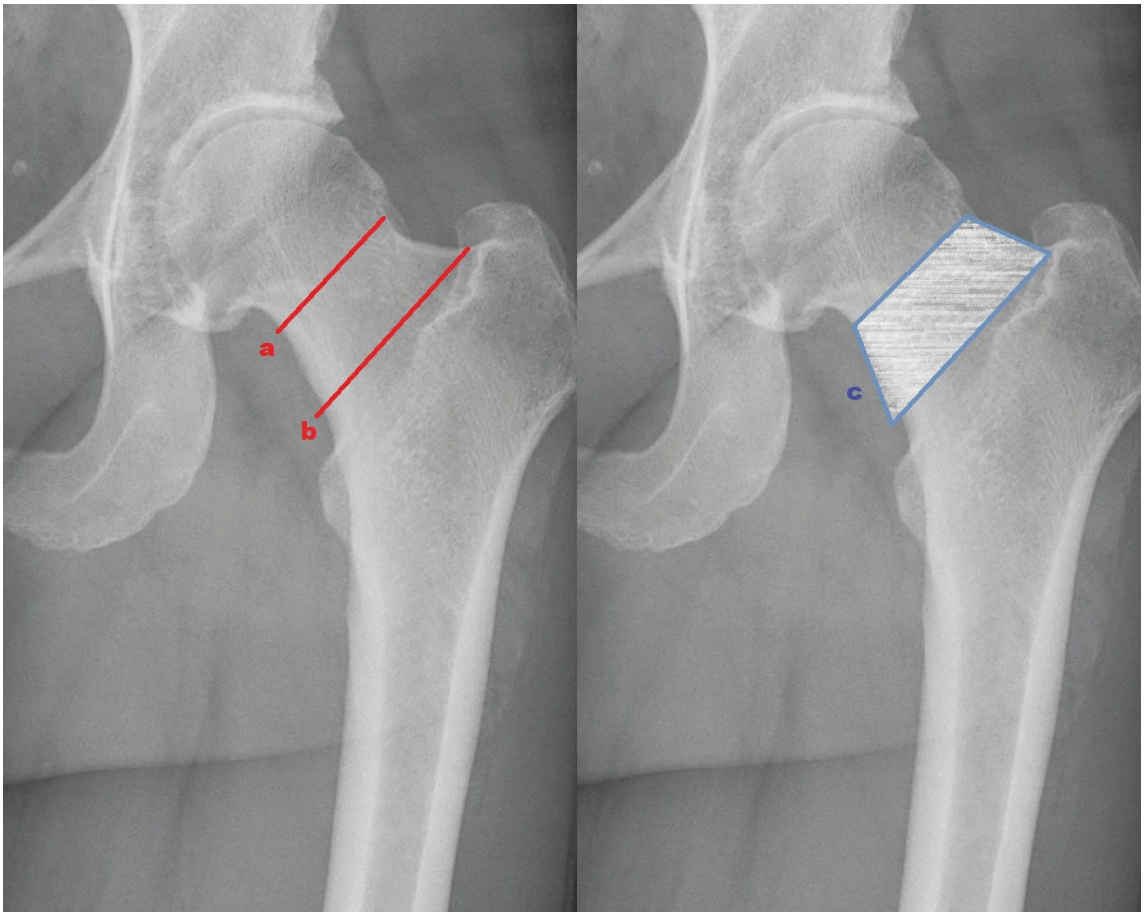

Figure 2: Whereas in neck-retaining (a) and neck-resecting (b) short-stem designs the osteotomy is performed standardized, in partially neck-retaining, calcar-guided short stems (c) the osteotomy is done individualized according to the patient's anatomy.

The third group in the classification by Jerosch consists of the partially neck retaining short stems (Figure 2c). Almost all new-generation short-stem designs derive from this group. They enable a great variability using a special calcar-guided implantation technique. An individualized level of resection of the femoral neck plays the most important role [13],[14]. The level of resection is individually chosen according to the preoperative planning in order to reconstruct offset and leg length [15]. The positioning of the implants thus can be varied [16]. Early representatives of these partially neck retaining implants are the Pipino-stem (Link) and the C.F.P. (Link). The newest generation of modern short stems consists exclusively of calcar-guided short stems, such as the Nanos-stem (Smith&Nephew), the Minihip-stem (Corin) and the optimys-stem (Mathys Ltd Bettlach) (Figure 3).

Figure 3: Partially neck retaining (calcar-guided) short stems (a: Nanos, Smith&Nephew, 2004; b: MiniHip, Corin, 2007; c: optimys, Mathys Ltd Bettlach, 2010).

CALCAR-GUIDED SHORT STEMS – WHAT'S THE PHILOSOPHY?

Modern calcar-guided short-stems have been increasingly used in THA in recent years [2]. Just like other short stems, they focus on sparing muscles, soft-tissue, and bone, thus allowing minimally-invasive (MIS) techniques and approaches to be successfully applied [3]. The possible benefits of calcar-guided short-stems, compared to alternative designs, can be accomplished through a special implantation technique, which differs from conventional techniques used with traditional straight-stem designs and different early short-stem designs. The most important aspect, in this regard, is the anatomical curvature, which has been adapted from the calcar. The positioning of the stem follows the individual anatomy alongside the calcar curve, and permits individualized implantation [14].

CALCAR-GUIDED SHORT STEMS – RECONSTRUCTION OF ANATOMY

Modern THA is largely dependent on the successful preservation of hip geometry.

The accurate reconstruction of the hip joint anatomy is crucial for the clinical outcome. The femoro-acetabular offset has increasingly come into focus [15]. Reduced offset might lead to gluteal insufficiency along with instability of the hip joint and increased risk of dislocation [17]. On the other hand, a severe increase in offset can cause trochanteric bursitis. Given these findings, it appears that undesired changes of offset have great clinical relevance.

Conventional straight stems provide diaphyseal anchorage along with a mostly standardized level of osteotomy of the femoral neck. The preexisting hip anatomy can only be reconstructed by using different offset-versions of the implant. In extensive varus anatomies for example, this often cannot be achieved properly (Figure 4). Valgization has been found to be the limiting factor in the successful reconstruction of hip geometry also in many previous short-stem designs, causing reduced offset and increased leg length [10].

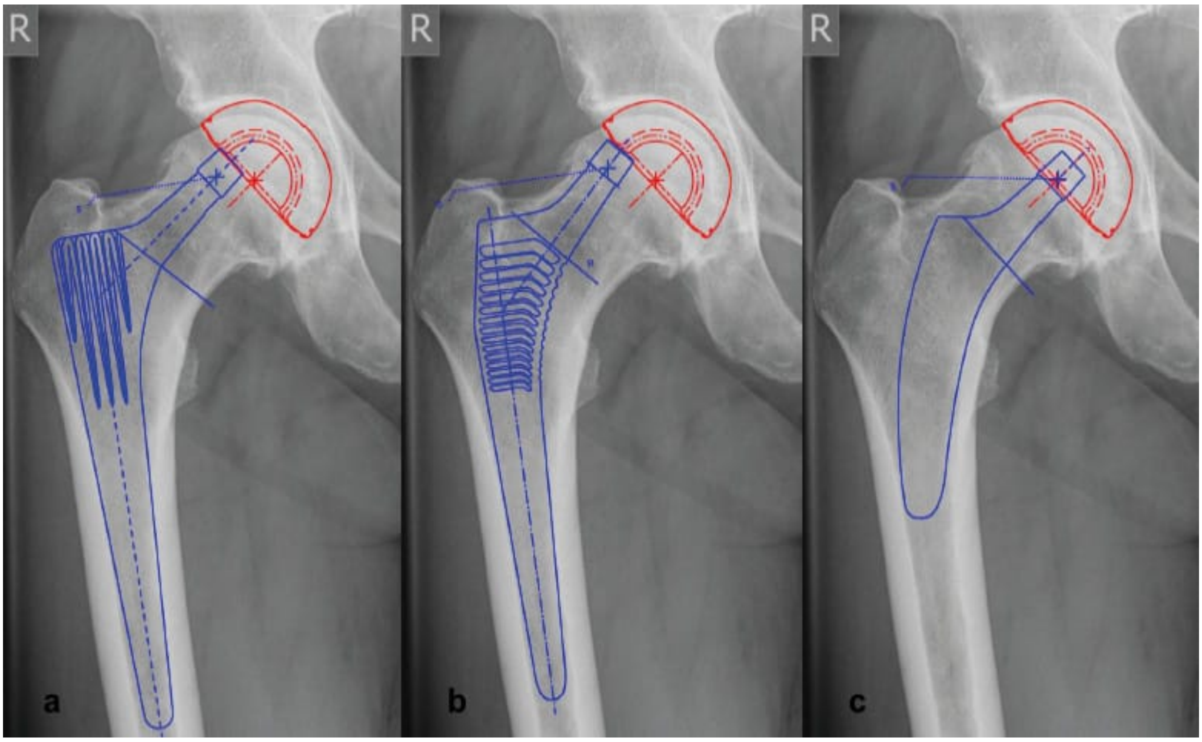

Figure 4: Reconstruction of offset in a varus hip using straight stems (a and b) and a calcar-guided short stem (c).

Reconstruction of the femoral offset is highly dependent on the ability to reproduce different CCD-angles [18]. The reconstruction of different CCD-angles, in this regard, seems to be the key to accomplish the retainment of the hip anatomy.

In calcar-guided short-stem THA, stem alignment can be individualized, which supports the successful reconstruction of the femoral offset [16]. Guiding the stem alongside the calcar, the positioning of the stem in the proximal femur is dependent on the resection level of the femoral neck. Given a preexisting varus anatomy, a high resection also results in a varus position of the implant, maintaining a large femoral offset. On the other hand, given a preexisting valgus anatomy, a low resection results in a valgus position, causing a small femoral offset [14] (Figure 5) Consequently, this allows a broad reconstruction of CCD-angles and thus enables a precise preservation of hip geometry.

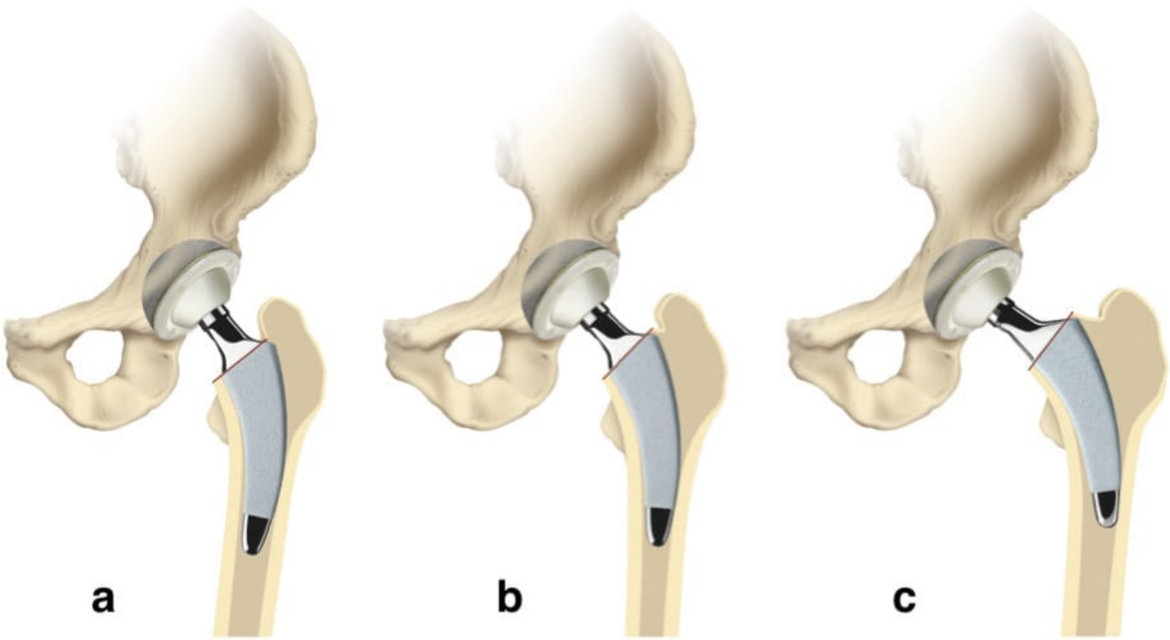

Figure 5: Depending on the resection level of the femoral neck, calcar-guided stems can be aligned individually according to the preexisting anatomy (a: valgus; b: neutral; c: varus).

CALCAR-GUIDED SHORT STEMS – PERFECTLY SUITABLE FOR MIS

The positioning of the rounded short stem alongside the calcar curve leads to another attribute of these implants. Unlike in conventional straight stem THA, given the short and rounded design the insertion of the instruments as well as the implantation can be done in the "round-the-corner" technique, sparing the greater trochanter region completely [13],[14](Figure 6). This is convenient, not only regarding the incidence of possible fractures to the trochanter, but also by reducing damage to muscle- and soft-tissue inserting at the piriformis fossa and the greater trochanter, such as the crucial gluteal muscles [8].

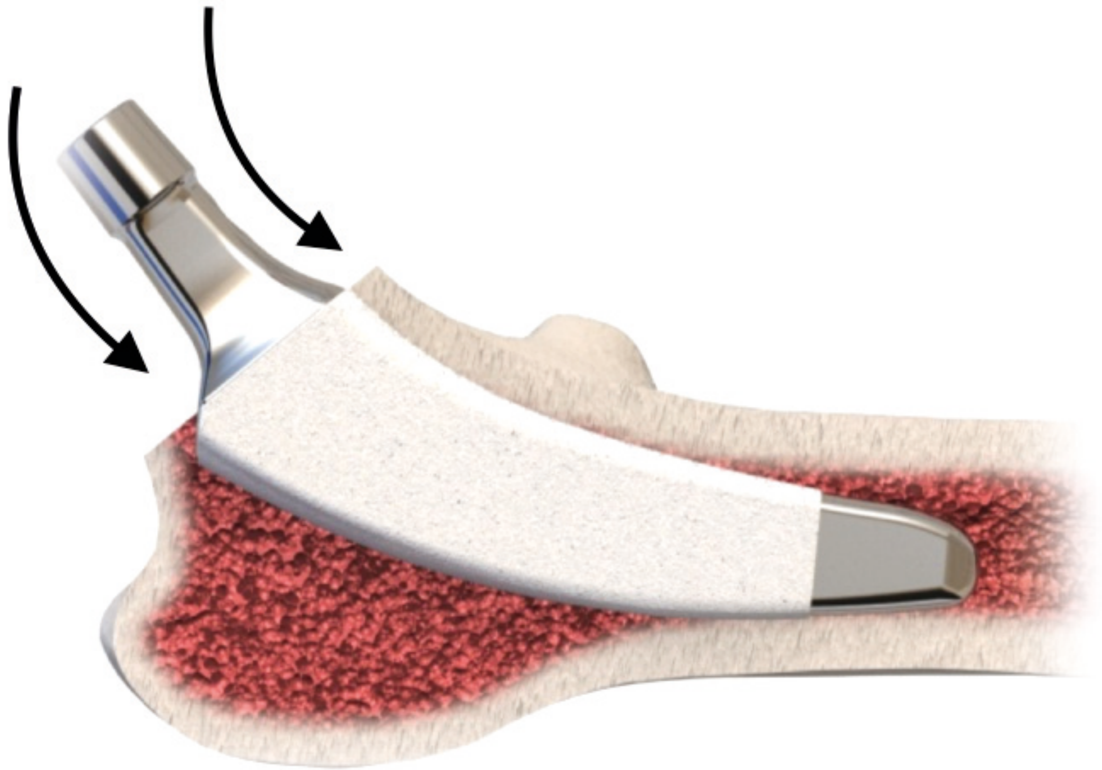

Figure 6: “Round-the-corner” technique of clacar-guided short stems.

The usage of minimally-invasive approaches, without transection or damage to the muscles, thus, is clearly facilitated using this technique [3].

Due to the short and curved design of calcar-guided short stems, the soft-tissue sparing implantation appears to be technically easy. However, the individualized implantation technique requires distinct knowledge about the characteristics of different varus- and valgus positioning. A learning curve for surgeons new to this technique must be taken into account [19].

CALCAR-GUIDED SHORT STEMS - OSTEOINTEGRATION

The conical design of all new-generation calcar-guided short stems aims at a sufficient wedging of the stem in the metaphyseal femoral bone, leading to high primary stability. Postoperative subsidence thus should be prevented and rotational stability should be ensured [20],[21]. This is particularly important striving for immediate postoperative full weight bearing, given young and active patients [22]. The pronounced metaphyseal anchorage of short stems also aims at a physiological loading of the proximal femoral bone. Thus, boney alterations such as stress-shielding and the formation of osteolyses are supposed to be minimized, which could be confirmed by existing studies [23].

Given a shortening of stem length in calcar-guided short-stem THA, primary stability potentially causes concerns [20]. The predominant type of fixation is metaphyseal anchoring, based on the fit-and-fill principle. However, due to the option of individualized positioning of these stem-designs, the type of anchoring differs distinctly. In varus alignment three-point anchoring is common with cortical contact to the lateral cortex of the partially resected neck, the medial calcar, and the lateral cortex at the tip of the stem. However, depending on positioning and sizing, especially in extensive valgus alignment, pronounced diaphyseal anchorage is possible. In those cases, a securely achieved cortical contact to the distal lateral cortex, as well as to the distal medial cortex is crucial. In valgus position a missing cortical contact of the tip has been frequently observed in the early collective including the learning curve, particularly in cases of undersizing. Therefore, surgeons should take into account that particularly in valgus hips, undersizing accompanied with a lack of contact to the lateral cortex, might cause initial instability and subsequent implant micromovement [16] (Figure 7). The usage of intraoperative fluoroscopy to identify undersizing of the stem is therefore highly recommended [14],[19].

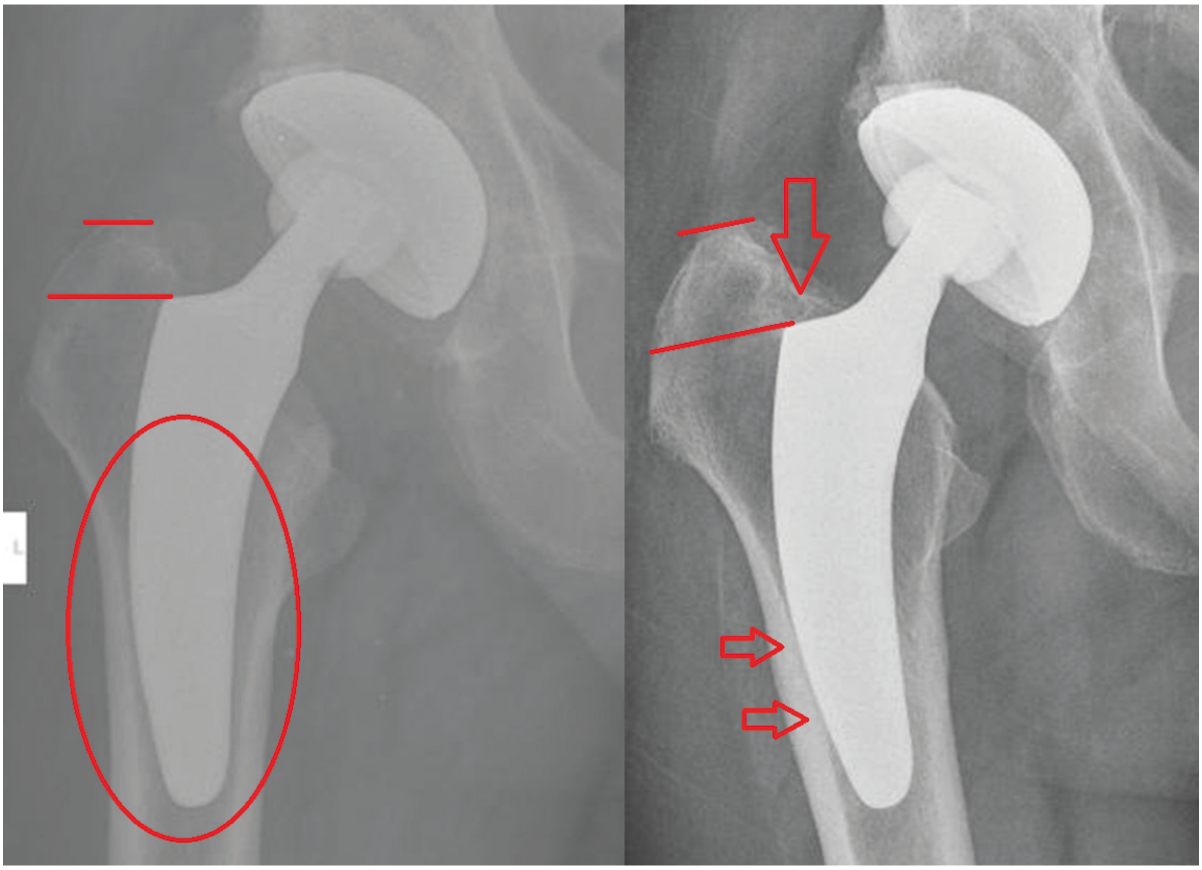

Figure 7: Undersizing of the stem without sufficient contact to the distal lateral cortex may lead to stem subsidence especially in valgus hips.

CALCAR-GUIDED SHORT STEMS – INDICATIONS

Indications for short stem THA have been constantly expanding in the last years. Originally short stems have been developed and thus have been primarily used in young in active osteoarthritis patients with high demands regarding postoperative function. In modern THA, this group of patients still is mainly to be treated with calcar-guided short-stem THA. However, also elderly patients and patients with limited bone quality increasingly are indicated for these implants with encouraging early results [24]. Age limits are not provided by the companies, however, in severe osteoporosis always a cemented implant should be chosen [25]. Recent studies indicate that subsidence might be increased in heavy weight patients, especially given immediate full weight bearing postoperatively [21].

CALCAR-GUIDED SHORT STEMS – REGISTRIES DON'T LIE

Recent data from the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) showed very encouraging cumulative revision rates, especially for the calcar-guided short stems Nanos and optimys. After one year, revision surgery had to be performed in only 0.8% and 0.3% respectively, while all short-stem designs in total resulted in a mean cumulative one-year-revision-rate of 1.6%, which is comparable to conventional stem designs (1.5%) **[26]**.

Also data from the Swiss Implant Registry (SIRIS) presented by Münger et al. regarding primary implantations of the conventional twinsys stem (Mathys Ltd., Bettlach) and the optimys stem of all primary implantations between 2012 and 2017 (2321 vs. 5741 cases), revealed a significantly smaller revision rate (number of revisions / total number of implantations) for the calcar guided short stem compared to the conventional stem (1.7% vs. 3.7%) **[27]**.

CALCAR-GUIDED SHORT STEMS – THE FUTURE?

Modern calcar-guided short-stem THA offers numerous distinct advantages. Short- and mid-term results are encouraging, however, long-term results to date are lacking. If the upcoming years and further registry data will continue to confirm comparable revision rates, in the future there will be no getting around calcar-guided short stems in modern THA.

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