

PROSTHETIC MANAGEMENT OF COXA VARA HIPS WITH INCREASED FEMORAL OFFSET: THE VALUE OF HIP RESURFACING

<https://doi.org/10.71165/kn50-ou4b>

AUTHORS

Julien Girard - Université Lille-Nord-de-France, Lille, France

Pierre Martinot - Université Lille-Nord-de-France, Lille, France

Julien Dartus - Université Lille-Nord-de-France, Lille, France

Sophie Putman - Université Lille-Nord-de-France, Lille, France

Henri Migaud - Université Lille-Nord-de-France, Lille, France

SUMMARY

Background: Restoration of the femoral offset is critical for joint stability, range of motion, and abductor muscle efficiency in hip arthroplasty, particularly in young patients. Hips characterized by "long-neck coxa vara" (femoral offset >40 mm and neck-shaft angle <125°) present significant reconstructive challenges, as standard non-modular stems often fail to restore anatomy without risking instability, limb length discrepancy, or premature loosening due to increased varus moments.

Objective: This study evaluates the radiographic and clinical efficacy of hip resurfacing arthroplasty (HRA) in reproducing native proximal femoral morphology and restoring function in young, athletic patients with high-offset coxa vara.

Key Points: A prospective study of 45 patients (mean age 46.6 years) with coxa vara and offsets exceeding 40 mm underwent HRA. At a mean 9-year follow-up, the Postel Merle d'Aubigné score improved from 11.1 to 17.7, and the Harris Hip Score increased from 50.3 to 97.5 ($p < 0.0001$). Radiographic analysis showed a non-significant mean offset reduction of 1.6 mm. The mean stem-shaft angle was 131.3°, representing a significant mean valgus gain of 8.7° relative to native anatomy ($p < 0.0001$). No cases of dislocation, revision, or limb length inequality exceeding 5 mm were recorded.

Conclusion: Hip resurfacing arthroplasty effectively restores native biomechanical parameters in complex coxa vara morphologies. By facilitating anatomical reconstruction and allowing for protective valgus positioning without compromising offset, HRA provides a durable alternative to conventional total hip arthroplasty in young, active populations, avoiding the complications associated with modular necks or custom implants.

KEYWORDS

Arthroplasty, Replacement, Hip; Hip Resurfacing; Coxa Vara; Hip Joint; Range of Motion, Articular

INTRODUCTION

During hip arthroplasty (THR) implantation, restoration of the femoral lever arm (offset) is a crucial element in order to maintain the stability of the prosthetic joint, improve joint amplitudes and optimize the efficiency and power of the gluteal muscles [1,2]. This last point is essential, especially when the implantation is performed on a population of young subjects who wish to resume their sports activities. Indeed, adequate gluteal tension is essential for resuming activities such as running or sports with impulses on the lower limb. A value of 40 mm is commonly accepted as the upper limit of the mean femoral offset [2]. Hips with a high lever arm are very frequently accompanied by a long femoral neck and are most often found in young men and rarely in women. This is referred to as "long-neck coxa vara".

Prosthetic replacement of these hips with increased femoral offset and long necks is difficult, because it exposes the patient to many risks: instability, lameness, lengthening to tighten the gluteals and unevenness of length, and muscle failure if the offset is not restored [2]. Few non-modular femoral pivots can restore an offset of more than 40 mm. When this is possible with specific stems with a reduced neck-shaft angle, the survival rate of these implants does not seem to be as favourable as the standard offset version, because of the increase in the varus femoral moment. Other options exist: custom-made implants, short stems, trochanterotomy for distalization and re-tensioning of the gluteals, hip resurfacing (HRT), etc. The latter, which we use on a daily basis in the department, seems in this context to represent an attractive alternative, since it allows automatic reconstruction of the joint morphology. The HTR has many theoretical advantages over conventional total hip replacements: preservation of the femoral bone stock, integrity of the femoral shaft, no risk of significant elongation (variations being < 5 mm) and instability, ease of subsequent revision surgery, resumption of sports with impact, etc. [3]. Furthermore, it should be remembered that the frontal position of the femoral THR implant should be slightly valgus (7°) in relation to the native neck angle. Thus, a THR implanted on a hip in 114° vara will have a frontal position of about 120° . This valgus position transforms the shear forces into compression forces exerted on the femoral neck, which appears to be beneficial from a biomechanical point of view and for the durability of the femoral fixation.

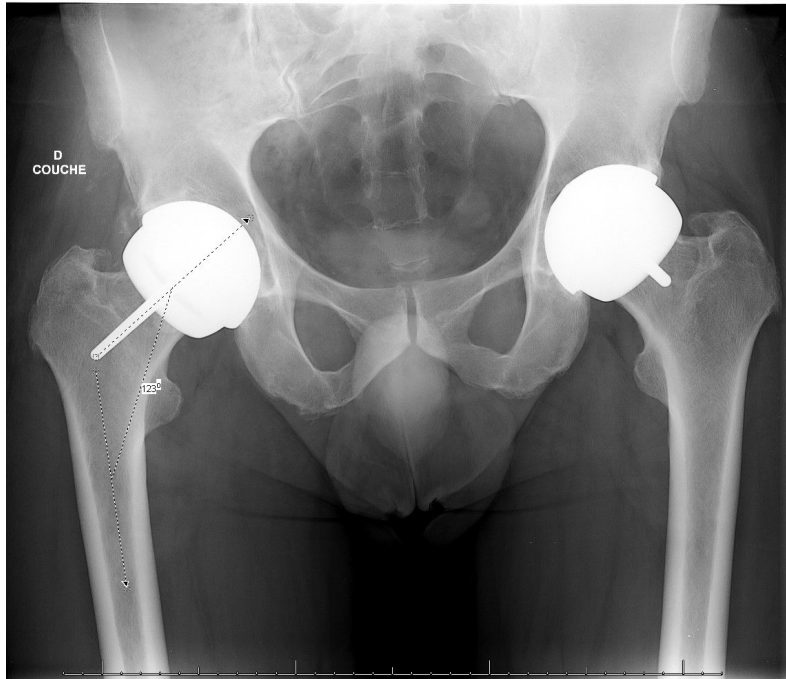


Figure 1: Patient with bilateral coxa vara arthrosis. The left side was operated on with a cementless femoral fixation RTH with a CC'D angle of 119° . The right side had a preoperative CC'D angle of 118° and a femoral offset of 59 mm.

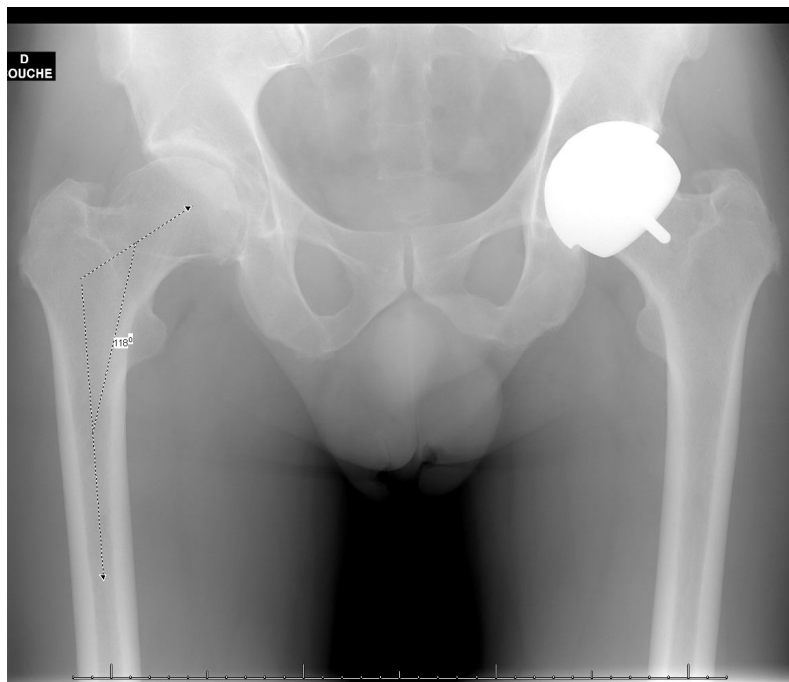


Figure 2: Postoperative radiographs show a cemented RTH on the femur with an SSA of 123° and a femoral offset of 57 mm. The femoral positioning was therefore slightly valgus by 5° .

METHODOLOGY

We have therefore analysed the reproduction of the femoral morphology of an implanted THR in a population of young and athletic patients with a coxa vara hip with increased femoral offset, based on a prospective radiographic study.

This work was based on a single-operator continuous prospective study (JG) of 563 THR performed from January 2010 to June 2011. Forty-five cases (45 patients) had a coxa vara hip (CC'D angle less than 125°) with increased femoral offset (greater than 40 mm). There were 4 women and 41 men.

Of these 45 patients, 38 played impact sports (running, football, basketball, handball, karate or volleyball). The mean age of this group was 46.6 years [18-62]. The mean Body Mass Index (BMI) was 26 [15-35]. The indication for surgery was primary coxarthrosis in all cases (no cases of fracture or femoral osteotomy). All patients underwent THR surgery (femoral implant with low-viscosity cement or cementless fixation; cementless fixation for the acetabulum) (Conserve + Wright Medical Technology, Arlington, Tennessee). All procedures were performed via a posterolateral approach under vertical laminar flow. Preoperative planning sought to restore the femoral offset anatomically by modulating the distal epiphyseal bone preparation. The gluteus maximus was never removed from the acromial line, and only a posterior superior capsulotomy was performed. The femoral implantation of the THR was no different from a standard case, except for the exposure of the acetabulum. The presence of the long femoral neck and vara altered the acetabular exposure [4] and, compared with standard coxarthrosis, the Hohman retractor had to be positioned higher on the anterior column in order to perfectly displace the neck superiorly and anteriorly with respect to the acetabulum. For femoral preparation, the procedure was simplified by the length of the neck. Once the hip has been dislocated and the femoral lifter has been positioned on the intertrochanteric line, the head and the head-neck junction are easily exposed. It was then easy to perform the femoral phase using the dedicated instrument set. The average operating time was 56 minutes [34-89]. All patients received non-steroidal anti-inflammatory drugs postoperatively to prevent heterotopic ossifications (Celecoxib (100 mg/24h for 10 days)).

All patients underwent a preoperative and final clinical evaluation including Devane, Postel Merle d'Aubigné (PMA) and Harris Hip Score. Global and sectoral joint ranges were recorded. Radiographic analysis was performed on a front view of the pelvis, with the limb internally rotated by 15 to 20°. Interpretation and reproducibility of the radiographic analysis between the postoperative and preoperative films was ensured by measuring pelvic tilt and rotation. Criteria for reproducibility of the images were used with the tip of the coccyx, which was considered centred if it was located between 2 and 4 cm from the pubic symphysis. This ensured that there was no significant variation in version and/or pelvic tilt. The neck/shaft angle was measured between points C, C', and D, where C is the centre of the femoral head, C' is the middle of the neck, and D is the middle of the femoral shaft. The femoral offset was measured as the perpendicular to the femoral shaft axis through point C. The Stem Shaft Angle (SSA) was measured on the recoil films by considering the axis of the femoral implant in relation to the cervical axis. If the implant was deviated from the femoral neck, this was indicated by a + in degrees (°), and if it was deviated, by a - in °.

Statistical analysis was performed using SAS™ software (SAS Institute, Campus Drive, Cary, NC, USA) by the Biostatistics Department of the Lille University Hospital. Student and Chi² tests were used for continuous and categorical variables.

RESULTS

All patients were reviewed with a mean follow-up of 9 years [8-10.4]. The Postel Merle d'Aubigné score increased from 11.1 points [8-14] to 17.7 points [16-18] ($p < 0.0001$). The Postel Merle d'Aubigné score for pain increased from 3.2 [1-5] to 5.7 [5-6], for mobility from 4.3 [3-6] to 5.8 [5-6] and for walking from 3.5 [2-5] to 5.8 [5-6] ($p < 0.0001$). The Harris score also increased from 50.3 [24-68] to 97.5 [87-100] ($p < 0.0001$).

At 8 years, no patient had a limp on walking and no Trendelenburg signs were observed. Patients reported an improvement in activity level as the Devane score improved from 2.7 [1-5] to 4 [2-5] ($p < 0.0001$). Global joint ranges improved from 150.7° [90-260] to 244° [190-300] ($p < 0.0001$) (Table 1).

	Flexion	Extension	Abduction	Adduction	External rotation	Internal rotation
Preoperative	91 [70-120]	3 [-10/30]	25 [0-50]	17 [0-30]	14 [-20/40]	2 [-15/20]
Retrospectively	116 [100-140]	10 [0-30]	32 [20-50]	32 [20-40]	28 [20-40]	23 [10-30]

Table 1: Evolution of joint mobility values between the pre-operative and final follow-up periods (in degrees).

The mean preoperative neck/shaft angle was 120.9° [114.7-125]. The mean femoral offset decreased from 53.8 mm [40.9-75] preoperatively to 52.3 mm [40-70] at follow-up, and this difference was not significant ($p > 0.05$, Table 2).

	Offset (mm)	CCD Preoperative & SSA Post-op	Harris Hip Score	PMA	Global mobility ($^\circ$)
Preoperative	53,8 [40,9-75]	120,9 $^\circ$ [114,7-125]	50,3 [24-68]	11,1 [8-14]	150,7 [90-260]
Postoperative	52,3 [40-70]	129,8 $^\circ$ [120-134]	97,3 [87-100]	17,7 [16-18]	243 [190-300]

Table 2: Evolution of clinical and radiological values between the pre-operative and the final follow-up periods.

The femoral offset was thus reduced by an average of 1.6 mm (6.7/-7.8), without this reduction being significant. The SSA angle at follow-up was 131.3° [118-134]. The mean valgus gain of the femoral implant compared to the native CCD bone angle was 8.7° (-4.6/14.8) ($p < 0.0001$). Compared to preoperative data, four patients were elongated by less than 5 mm. No dislocations or thromboembolic events were observed. No hips were revised at the longest follow-up and we did not observe any Adverse Reaction to Metal Debris complications.

DISCUSSION

Anatomical reconstruction may be subject to considerable variations during the implantation of a THP. The biomechanical parameters (femoral offset, centre of rotation, length, etc.) can be modified to a great extent, depending on the preoperative planning and the type of implantation performed. This is impossible with an HTN because, by definition, the reproduction of the anatomy is almost "automatic", which is a major advantage in complex cases. Coxa vara morphologies with increased femoral offset represent a challenge in terms of anatomical reconstruction, as most standard femoral stems do not allow such an offset to be restored. But the corollary for the THP is also that it cannot correct important anatomical anomalies. Thus, it is impossible with a THR to lengthen, shorten or increase the femoral offset. Indeed, while the femoral stems of THR have standard or lateralized versions and the modularity of the prosthetic heads (short, medium, long or even extra-long neck) is present, the prosthetic configuration is multiple. The RTH is a monobloc and therefore has no possibility of modularity of implantation. In cases such as this one with a long vara neck, "automatic" reproduction by the HTN seems to be an attractive feature, but it is still necessary to ensure that implantation in such cases does not lead to

long-term fixation problems. Indeed, certain biomechanical factors must be respected. For example, even in such cases, it is imperative to keep the femoral component in a valgus position (of the order of 7°) in order to reduce the loosening moment of the femoral component. It is therefore essential to understand that each THR must be adapted to each femoral morphology, and a constant position of 140° SSA angle is a mistake that should not be made. This is a major difference from THR, where the femoral stem is anchored in the femoral shaft and does not allow for adaptability of the femoral morphology. In fact, on a femur vara at 115° , it would be absurd to deliberately implant a femoral pivot of a THP in varus to reproduce the anatomy and increase the offset. In this case, a 3-point bearing would be automatic and would lead to thigh pain in the short term, and then, because of a high varus moment, to bone remodelling in Gruen's zone 3, and then potentially to loosening of the femur... On the other hand, in our series, at 9 years' follow-up, we have seen no problems with femoral fixation in these hips, whose unusual morphology leads to significant femoral stresses. This is due to the fact that the femoral shaft is free of any implant, and that the transmission of stresses remains physiological in healthy cortical bone. The stresses exerted are thus identical to those of a virgin hip, which can be a major advantage of the HTR configuration.

In the case of the THR, it must also be taken into account that valgus positioning of the femoral component may result in a theoretical decrease in femoral offset. This was not confirmed in our study, since the variations observed were not significant. It is essential to valgize the implant while maintaining the same femoral centre of rotation. Thus, valgization will not result in any loss of femoral offset.

The following anatomical values for a normal coxofemoral joint are accepted: a cervicodiaphyseal angle (CC'D) of about 130 to 135° and an offset of less than 40 mm. In our study of HTR on long-necked vara, there was a small, non-significant decrease in the femoral offset (-1.5 mm). Although this decrease does not appear to be significant, it is important to know whether it has a negative impact on clinical function (especially since we are dealing with an athletic population in which gluteal motor function is crucial). Our results show that the clinical and functional scores are comparable to those observed in hips of normal morphology. Moreover, although these were hips with a high-risk morphology, we did not observe any lameness in retrospect and the walking item of the PMA score was always higher than 5. The second point is to know if the implantation of a THR in such conditions generates a risk of length inequality. In our study, the restoration of the offset associated with moderate valgization did not result in any case of lower limb length inequality of more than 5 mm. This compares with the significant risk of problematic lengthening (more than 1 cm) with THR implantation in this type of coxal morphology [5]. The rate of lower-limb length inequality after THR on coxa vara and long neck is not well defined in the literature, but every hip surgeon knows that this risk is frequent and difficult to anticipate with standard implants. Indeed, the neck vara frequently induces a small stem size and therefore a low offset; either the femoral stem has to be "perched" to get closer to the native offset, but then the limb is lengthened...

For this reason, there are other prosthetic solutions to restore the anatomical and biomechanical parameters of the hip in cases of severe deformity. All these methods must be based on accurate preoperative planning, as shown by Sariali et al [6], who used CT scans to implant the planned prosthesis in 86% of cases, while respecting the femoral offset (average difference between preoperative and postoperative offset of 0.8 mm). However, in order to achieve this result, modular-neck posts were required. It is now generally accepted that these necks cause certain problems: risk of corrosion (if the neck is made of Chrome-Cobalt), of disunion, of fracture of the modular cone (if the neck is made of Titanium), and of ARMD-type complications. Corrosion at the modular neck-stem junction is greatly increased when a long (+6 mm) "offset" modular neck is used, which is frequently necessary for these coxa vara hips. This corrosion has even been the cause of pseudo-tumours observed with ceramic-ceramic, rather than metal-metal pairs [7]. Similarly, the risk of fracture of the modular neck is increased by the use of long necks, which are frequently required for these coxa vara hips. The use of modular necks should therefore be cautious, or even discouraged, in hips with a long-neck coxa vara morphology. It is also interesting to note that the

use of modular collars restored the offset with a low average variation (2.1 mm) but with very large extremes. Thus, out of 120 hips with stems with increased offset and modular neck, 44 had a decreased offset and 76 an increased offset, and 2 cases of dislocation occurred [2].

One-piece femoral stems pose different problems in reproducing the morphology of these vara hips, even though their use appears to be safer. Massin et al [8] have shown that with a set of 15 implant sizes, with 3 different metaphyseal configurations and 2 neck-shaft angle options, offset could be restored at the planning level in 86% of cases. However, the stock of implants required is very large and not in line with the current trend of cost optimization. In addition, there are still 14% of hips that do not have an anatomical reconstruction. Finally, this is only based on planning data and has not been proven in practice. In addition, the use of pins with increased femoral offset has frequently resulted in reduced arthroplasty survival compared to the same standard implants due to excessive stress on the femoral fixation. For example, we have found that femoral implants with varied necks (Lubinus SP2 117°) reproduce the anatomy of coxa vara hips better than standard implants, but are more prone to femoral loosening (7% at 6 years' follow-up, Fig. 3) and do not prevent dislocation (5.4%) [9].

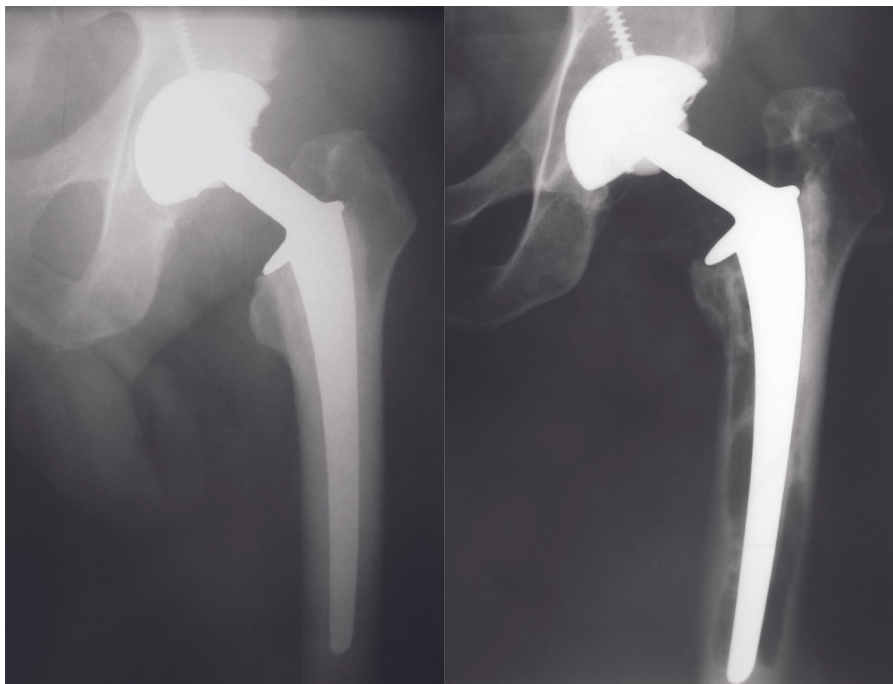


Figure 3: Loosened at 7 years of age of an SP2 117° XL post implanted to restore the native offset. Osteolysis occurred and the post sank at 7 years follow-up. An exacerbation of the varus moment on the stem probably induced an excess of stresses at the stem-cement interface and led to this aseptic loosening.

Another option is to perform a trochanterotomy, which allows the gluteals to be tightened while using a standard offset pivot, but this technique exposes the classic risks of trochanterotomies (pseudarthrosis, lameness, bursitis, etc.), and induces a longer postoperative convalescence than with a conventional approach, and does not solve the problem of the coxa vara neck (the risk of elongation is then increased)

An attractive option is the use of custom-made femoral stems [10]. This concept seems to be the ideal solution because of its ease of use and restoration of anatomical parameters. A single rasp, a single implant, and optimal preoperative planning based on 3D imaging seem to be arguments in its favour. This alternative induces de facto the realization of a dedicated imaging (3D CT), of a preoperative study in collaboration with the laboratory manufacturing the post in order to adjust the offset, the CCD angle of the stem and the length. Unfortunately, some disadvantages temper these advantages somewhat. Some of them are not very important, such as the delay caused by the procedure and postponing the surgery by a few weeks, the time spent on planning with the manufacturer or the need to perform a CT scan (and therefore the additional cost and radiation imposed on the

patient). The cost of the custom-made stem (reimbursed at 2489 € whereas standard stems are reimbursed at between 588 and 919 €, i.e. an additional cost of 2 to 5 times) seems to be a non-negligible element and, depending on the country, may be borne by the patient or the company. It may also happen that the custom-made rasp may under or overestimate the compaction of the cancellous bone. If the cancellous bone appears to be of poor quality, the rasp will sink deeper than expected and the custom stem will drop lower and induce shortening and/or potential loss of offset. [11]. It also happens that for very large offsets, the company producing the implant will not reproduce it, so as not to compromise the durability of the fixation (figure 4). In such cases, the biomechanical constraints on the stem are major and may even lead the company to modify the type of fixation (cemented or cementless).



Figure 4: Left coxarthrosis with a 66 mm offset and 121° vara neck in a 72-year-old man weighing 105 kg. The custom implant manufacturer indicates that "it is preferable to propose a cemented implant. Indeed, the femur is very variable and the neck very long. Given the patient's weight, the stresses on the calcar are enormous and this can lead to a risk of poor fixation of the stem. In view of his age, we prefer to propose a stainless steel stem to be cemented. Moreover, as the canal is narrow, in order for the cemented stem to pass our mechanical resistance criteria, we propose a cemented implant that is not undersized compared to the rasp. The neck of the prosthesis is the most varied and shortest we can design. The corrections obtained make it possible to compensate for osteoarthritis and limit the already significant prosthetic offset. In fact, the femoral offset with the custom stem is reduced by 7 mm with a shortening of 5 mm.

The last option is the current development of short stems. Theoretically, there appear to be many advantages: facilitation of a mini-invasive approach, preservation of the femoral bone stock and soft tissues, reduction of shielding stress, reduction of thigh pain, theoretical facilitation of extraction, reliable restoration of offset (even in extreme cases)... This last point is particularly important in cases of long-neck coxa vara. This last point is particularly important in cases of long-necked coxa vara. In such cases, it is advisable to adapt the placement of the short stem by increasing the height of the neck (Fig. 5).

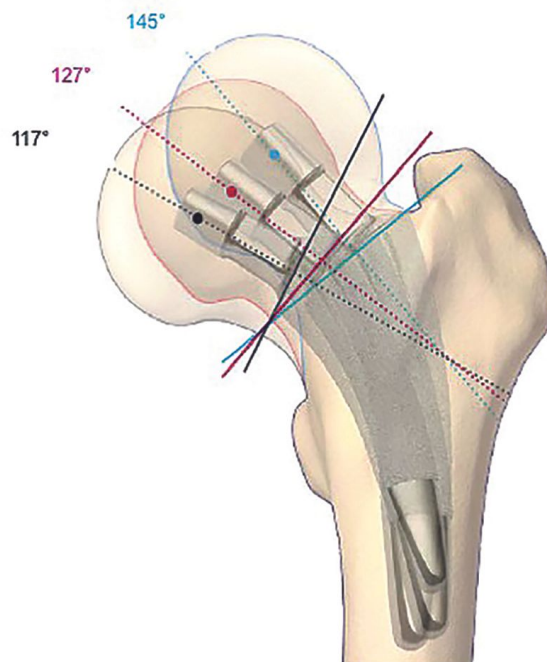


Figure 5 : Modification of the height and obliquity of the femoral cut with a short monobloc stem according to the preoperative CC'D angle. With the same implant, the CC'D angle can be varied from 117° to 145° by modifying the axis of introduction of the stem.

This allows the stem to be positioned in varus with greater support on the calcar. It is therefore often necessary to use a smaller implant than planned. The importance of planning is paramount because the height of the neck cut will induce a valgus or varus positioning of the implant. While this can be considered for moderate femoral deformities (+ or - 10° of a normal CC'D angle and + or - 5 mm of a normal offset (30-40 mm)), it can be problematic for major anatomical anomalies. Implanting a short stem on a hip with a long neck coxa vara will result in the positioning of a small short stem in a large vara (Figs. 6 and 7).



Figure 6 and 7: Coxarthrosis on coxa vara long neck. The CC'D angle is 120° with a femoral offset of 59 mm. The subcapital cut was relatively vertical with varus insertion of the short monobloc stem, responsible for a 3-point bearing (notably of the stem tip against the lateral cortex of the femur). Despite the use of a non-lateralized stem, the offset was increased.

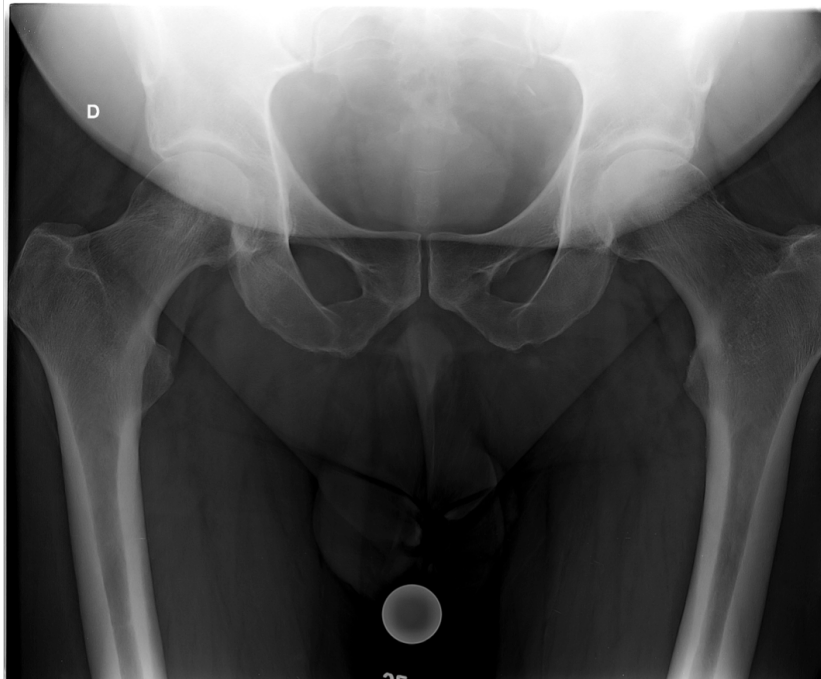


Figure 6 and 7: Coxarthrosis on coxa vara long neck. The CC'D angle is 120° with a femoral offset of 59 mm. The subcapital cut was relatively vertical with varus insertion of the short monobloc stem, responsible for a 3-point bearing (notably of the stem tip against the lateral cortex of the femur). Despite the use of a non-lateralized stem, the offset was increased.

The risk of 3-point fixation is increased. The physiological transmission of stresses seems to be disturbed by this stem, which has a predominantly cervical anchorage. The increase in varus stresses on a small, short stem may reduce the durability of fixation by tilting the implant. There is no long-term series of short stems implanted on long-neck coxa vara. In the present state of knowledge, it seems reasonable to restrict the use of short stems to coxarthroses on hips with a relatively standard anatomy, and not to implant them on extreme deformities, so as not to compromise their development.

CONCLUSION

Long-neck coxa vara hips, like short-neck coxa valga hips, represent a real prosthetic challenge. Not only must the highly deformed anatomy be reproduced, but the patient must also be assured of the longevity of the femoral fixation. There are many options, of which THR seems to be the most attractive solution in a young population. THR allows correct restoration of the femoral offset, while respecting the requirements of the technique (valgus). The 9-year follow-up seems to guarantee the durability of the femoral fixation of the implants.

REFERENCES

- [1] **McGrory BJ, Morrey BF, Cahalan TD, An KN, Cabanela ME.** Effect of femoral offset on range of motion and abductor muscle strength after total hip arthroplasty. *J Bone Joint Surg (Br)* 1995;77:865-9.
- [2] **Lecerf G, Fessy MH, Philippot R, et al.** Femoral offset: anatomical concept, definition, assessment, implications for preoperative templating and hip arthroplasty. *Orthop Traumatol Surg Res* 2009;95:210-9.
- [3] **Girard J, Lavigne M, Vendittoli PA, Roy AG.** Biomechanical reconstruction of the hip: a randomised study comparing total hip resurfacing and total hip arthroplasty. *J Bone Joint Surg (Br)* 2006;88:721-6.
- [4] **Girard J.** Le resurfaçage de hanche. *Encyclopédie Médico-Chirurgicale, Techniques chirurgicales Orthopédie-Traumatologie*, Ed Elsevier Masson SAS (Paris), 2013, 36-44.
- [5] **Herman KA, Highcock AJ, Moorehead JD, Scott SJ.** A comparison of leg length and femoral offset discrepancies in hip resurfacing, large head metal on metal and conventional total hip replacement: a case series. *J Orthop Surg Res* 2011;29:6:65.
- [6] **Sariali E, Mouttet A, Pasquier G, Durante E, Catone Y.** Accuracy of reconstruction of the hip using computerised three-dimensional preoperative planning and a cementless modular neck. *J Bone Joint Surg (Br)* 2009;91:333-40.
- [7] **Asencio G, Essig J, Nourissat C.** Réaction tissulaire locale anormale après prothèse totale de hanche avec modularité fémorale en chrome cobalt. *Rev Chir Orthop Traumatol* 2011;97 Suppl 7:260.
- [8] **Massin P, Geais L, Astoin E, Simondi M, Lavaste F.** The anatomic basis for the concept of lateralized femoral stems: a frontal plane radiographic study of the proximal femur. *J Arthroplasty* 2000;15:93-101.
- [9] **Bachour F, Marchetti E, Bocquet D, Vasseur L, Migaud H, Girard J.** Radiographic preoperative templating of extra-offset cemented THA implants: how reliable is it and how does it affect survival? *Orthop Traumatol Surg Res* 2010;96:760-8.
- [10] **Flecher X, Pearce O, Parratte S, Aubaniac JM, Argenson JN.** Custom cementless stem improves hip function in young patients at 15-year follow-up. *Clin Orthop Relat Res* 2010;468:747-55.
- [11] **Reize PK, Wulker N,** The adaptive custom-made – our reasons for not using it anymore. *Int Orthop* 2007; 31(2): 217–222.