Correlation between groin pain and cup design of hip-resurfacing implants: a prospective study

Julien Girard · Erwan Pansard · Reda Ouahes ·
Henri Migaud · Cyril Delay · Laurent Vasseur

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Abstract

Purpose Cup design has been incriminated as the source of groin pain after hip resurfacing but has not been well described; thus, it was assessed in a prospective study looking at three implant types.

Methods A group-match was done between three groups of hip resurfacing devices according to age, sex, body mass index, activity level, osteoarthritis aetiology and pre-operative scores.

Results The global groin pain rate was 5.7 % at six months and 2.7 % at last follow-up. Groin pain rate was significantly different between the three groups ($p=0.004$) and had a strong influence on the subjective results ($p=0.04$). No groin pain emerged between six months and last follow-up. No clinical differences were noted in Harris hip score and Merle d'Aubigné-Postel score at last follow-up. However, the Oxford hip score and Devane activity score were significantly lower for cups with macrostructures.

Conclusion The low groin pain rate in this prospective cohort was probably secondary to the specific surgical technique used and seems to be correlated with cup design.

Macrostructures on the external part of the cup could be significantly harmful.

Keywords Groin pain · Hip resurfacing · Metal-on-metal bearing · Coating

Introduction

Metal-on-metal hip resurfacing arthroplasty (HRA) has gained popularity for treatment of young, active patients with degenerative disease of the hip [1, 2]. In fact, because of appropriate quality friction torque, considerable stability with a very low dislocation rate, restoration of gait parameters and the non-operated proprioception that this implant type provides, HRA allows satisfactory return to high-level activities [3–5]. However, groin pain could be due to the specific full metal alloy cup design combined with certain surgical features. Groin pain after HRA appears to be more frequent than after conventional total hip arthroplasty (THA) [6, 7]. Bin Nasser et al. [6] reported that groin pain incidence increased to 18 % after HRA whereas it ranged from 0.3 % to 4.3 % after THA. Causes were multifactorial: infection, loosening, metal hypersensitivity, impingement of bony structures or ilio-psoas tendon, capsule irritation or implant malposition, heterotopic ossification, etc. [7–9]. Groin pain could be secondary to other regional pathologies (neurological or vascular lesions, referred pain from spine, knee, retroperitoneum or abdomen tendinopathies) [8]. This high rate appears to be correlated with younger age [9] or female gender [10]. Moreover, groin pain after HRA alters clinical function [11].

Large diameter heads have positive attributes in HRA, namely, increased stability, favourable lubrication properties and decreased wear, but are involved in psoas tendon impingement [9, 10, 12, 13] by sharp transition from the femoral head to the neck, with the head rubbing against synovium and

This study was performed in the Department of Sports Medicine, University of Lille, F-59045 Lille Cedex, France.

J. Girard · E. Pansard · R. Ouahes · H. Migaud · C. Delay ·
L. Vasseur

Department of Orthopaedic Surgery, Roger Salengro Hospital, 2
Avenue Oscar Lambret, Lille 59037, France

J. Girard (✉)
Department of Sports Medicine, University of Lille 2, 59045 Lille,
Cedex, France
e-mail: j_girard_lille@yahoo.fr

E. Pansard
Service d'orthopédie, Hôpital Raymond-Poincaré, 104, avenue
Raymond-Poincaré, 92280 Garches, France

capsule [11]. Cup malposition has been postulated to be the cause of groin pain in HRA. A lateralized or retroverted position exposes the anterior metal wall of the cup above the anterior bony acetabular wall and elicits iliopsoas tendonitis [13]. Lavigne et al. [11] suggested that cup design transmitted peak load differently to peri-acetabular bone than traditional THA.

To ascertain the role of HRA cup design in groin pain after hip resurfacing, we conducted a prospective study analysing the groin pain rate according to three implant types.

Materials and methods

Between July 2008 and November 2009, three different types of HRA devices were implanted successively in our institution by a trained hip surgeon (JG): group 1 – DynaMoM implants (Tornier SA, Saint Ismier, France); group 2 – Durom implants (Zimmer, Warsaw, IN, USA); group 3 – Conserve Plus devices (Wright Medical Technology, Arlington, TN, USA). The three implants used were thick monoblock cobalt-chromium (CoCr) cups. Conserve Plus was made from cast CoCr alloy that had undergone heat treatment, and DynaMoM and Durom devices were produced from forged CoCr alloy. The Durom cup component shape is not a hemisphere, rather with a sector angle of 165° and a flattened dome. Primary fixation was completed with three equatorial fins. DynaMoM fixation was secondary to an equatorial press fit on two thirds of the cup with exact fit in the dome area. The DynaMoM cup is a macro-textured acetabular component with macrostructures all along the cup. Conserve Plus cup was designed with a 170° low profile shell without any external macrostructures and with smooth edges. All HRAs were collected prospectively.

Males over 65 years of age and females over 55 years with proven osteoporosis diagnosed by densitometry or severe anatomical deformities were excluded from HRA. Other exclusion criteria were avascular femoral head necrosis with

large femoral defects (more than one third of femoral head), renal insufficiency, pregnancy and metal allergy.

We paired patients from each of the three groups according to age, sex, body mass index, activity level, osteoarthritis aetiology and pre-operative scores, i.e. Devane activity score [14], Harris hip score [15] (HHS), Oxford hip score [16] (OHS), and Merle d'Aubigné-Postel score (MDP) [17]. This pairing gave a prospective cohort of 264 patients (264 HRAs) with 76 cases in group 1, 93 in group 2, and 95 in group 3. Follow-up was significantly different for the three groups according to the successive implantation of each device during the inclusion period. Patient characteristics are described in Table 1. All patients gave written informed consent for inclusion in the study, which was approved by our institutional Ethics Review Board.

All procedures were conducted under general anaesthesia via a gluteus maximus muscle-split posterior approach with patients in lateral position. The short external rotators were released and only a posterior capsulotomy was performed (no anterior capsulotomy was undertaken). We never release femoral expansion of the maximus gluteus and/or the gluteus medius from iliac crest. The femoral instrumentation served to align and position the guide rod for femoral head preparation. The femoral head was then dislocated anteriorly and the acetabulum reamed sequentially. Peripheral acetabular osteophytes were excised to prevent a cam effect. The definitive cup component was impacted, always leaving at least 1 or 2 mm of bone over-covering the cup. Eventual “over-reaming” of the acetabulum (compared to acetabular reaming which would be done in conventional hip arthroplasty) was noted. This “over-reaming” procedure was done to optimise the head-neck ratio in order to avoid a cam effect if it was judged necessary by the operator. The femoral implant was positioned and secured with cement. The choice of femoral component size for hip resurfacing depended on a balance between restoration of the head-neck diameter ratio and acetabular bone conservation [18, 19]. An effort was made to

Table 1 Patient characteristics in the three study groups

	Characteristic	Group 1	Group 2	Group 3	p value
	No. of cases	76	93	95	
	Male patients ^a	53 (71.6 %)	62 (66.7 %)	59 (62.8 %)	0.5
	Age ^b (years)	48.3±13.3	46.6±11.8	47.6±12.1	0.6
	Body mass index ^c	26.1±4.9 (17–43)	25.2±4.8 (15–47)	26±4.9 (16–43)	0.4
	Diagnosis ^a	OA: 67 (88.2) ON: 9 (11.8) Others: 0 (0)	OA: 80 (86) ON: 10 (10.7) Others: 3 (3.2)	OA: 84 (88.4) ON: 9 (9.5) Others: 2 (2.1)	0.1
	Devane score pre-op. ^d (points)	2.8 (1–5)	3.0 (2–5)	2.8 (1–5)	0.2
	OHS pre-op. ^c (points)	40.5±5.2 (24–55)	39.3±4.2 (25–55)	39.7±4.1 (31–52)	0.2
	HHS pre-op. ^c (points)	48.6±11.6 (23–71)	51.6±12 (27–83)	45.6±11.8 (22–68)	0.5
	MDP pre-op. ^d (points)	10.9 (7–15, 11)	10.9 (4–15, 11)	10.5 (7–14, 11)	0.4
	Follow-up ^d (months)	36 (24–43, 19)	49 (34–57, 36)	26 (24–31, 16)	0.001

^a Values are patient numbers, with percentages in parentheses

^b Values are means and standard deviation

^c Values are means and standard deviation, with range in parentheses

^d Values are means, with range and median in parentheses

restore normal offset of the anterior femoral neck by removing anterior neck osteophytes, translating the femoral component anteriorly, or performing careful femoral neck osteoplasty when necessary [20]. The target for acetabular component position was 45° of abduction and 20° of anteversion in all cases. The hip was then reduced and the short external rotators and gluteus maximus tendon were repaired. Immediate full weight-bearing was allowed with two crutches during the first week. No restriction was applied to hip mobility; rehabilitation was supervised by a physiotherapist three times per week. Mean length of hospital stay was 6.1 (four to eight) days. Sports activities without any restriction were permitted post-operatively after a clinical control performed by the surgeon at six weeks post-operative [21].

Patients were reviewed at six months, one year and annually thereafter. Outcome measures were OHS [16], HHS [15], Devane activity score [14] and MDP [17]. The presence or absence of groin pain was verified at six months, one year and annually thereafter, by the same independent observer who had not participated in clinical care. Patients were asked about their medication needs for groin pain and its intensity (slight, moderate or intense). To be considered as pain, symptoms needed to be present daily or substantially enough to modify daily living activities. Groin pain location was defined as the area extending from the inner thigh to the anterior border of the greater trochanter and from the anterior superior iliac spine to the base of the greater trochanter.

Antero-posterior radiographs of pelvis were taken at six months, one year and annually thereafter, with the legs positioned at 15° of internal rotation. They were rejected if the coccyx was not centered on the pubic symphysis and was not located within 2–4 cm proximal to it. This ensured proper positioning of the pelvis in both frontal and sagittal planes [22]. Presence of heterotopic bone formation was identified according to Brooker et al. [23]. Implant positioning was evaluated by an independent observer. Acetabular cup inclination (α angle), lateralisation, anteversion and anterior femoral head to neck offset were measured [20]. If groin pain was present after six months, X-rays and puncture aspiration ruled out loosening or infection. If negative, iliopsoas conflict was investigated clinically by the psoas stretch test and pain measures during activities involving active hip flexion [15, 24] as

well as by ultrasound examination and computed tomography (CT). An iliopsoas conflict was suspected when CT shows an overflowing cup at the anterior acetabular wall. Patients with suspected iliopsoas tendinitis were first managed with oral anti-inflammatory medications. If it persisted, they were infiltrated under CT with xylocaine and long-release corticosteroids to confirm and treat the tendinopathy [7].

Statistical analysis

Relationships between categorical variables were investigated by the chi-square test, and ordinal variables by the Kruskal-Wallis test. Discrete variables between cohorts and at different stages of follow-up were compared by analysis of variance and Student's t-test. When samples were small or independent, non-parametric tests were applied (Wilcoxon, Mann-Whitney and Fisher's exact test). Logistic regression analysis determined if any of the following variables were associated with groin pain at six months and at last follow-up: implant type, cup size, acetabular over-reaming, α angle, rotation center lateralisation, anteversion and anterior cup offset. The significance level accepted was $p < 0.05$ for all statistical analyses with SPSS 15.0® software (SPSS, Inc., Chicago, IL, USA).

Results

This series included 264 patients with a mean age of 47.1 years (28–62) and mean follow-up of 49.5 months (38–57). At six months of follow-up, groin pain affected 15 patients (5.7 %) from the entire cohort. Eight of them took analgesics for their groin pain (3 % of 264 implants and 53 % of 15 patients with pain). Pain severity is reported in Table 2 which showed a statistical difference between the three groups at six months and one year of follow-up. Pain was not caused by early infection or loosening. Groin pain was statistically related to implant type ($p = 0.004$) and cup size ($p = 0.03$). Other studied characteristics were not statistically correlated with groin pain (Table 3), which was statistically more frequent in group 1 ($p < 0.05$). It afflicted ten patients in group 1 (13.1 %),

Table 2 Groin pain intensity at six months and at last follow-up (FU)

Pain level	Group 1		Group 2		Group 3		Entire cohort		p	
	Six months	Last FU	Six months	Last FU	Six months	Last FU	Six months	Last FU	Six months	Last FU
Slight	1 (1.3 %)	0	2 (2.1 %)	1 (1 %)	1 (1 %)	0	4 (1.5 %)	1 (0.3 %)		
Moderate	6 (7.9 %)	3 (3.9 %)	1 (1 %)	0	1 (1 %)	1 (1 %)	8 (3 %)	4 (1.5 %)		
Intense	3 (3.9 %)	2 (2.6 %)	0	0	0	0	3 (1.1 %)	2 (0.8 %)		
Total	10 (13.1 %)	5 (6.6 %)	3 (3.1 %)	1 (1 %)	2 (2.1 %)	1 (1 %)	15 (5.7 %)	7 (2.7 %)	0.004	0.04

Table 3 Radiological findings and correlation with groin pain and groin pain-free groups at six months

Measure	Groin pain	No groin pain	<i>p</i> value
Cup size (mm)	56.9±2.9	54.7±4	0.03
α angle (degrees)	45.8±6.7	43.9±6.9	0.3
Lateralisation (mm)	1.2±3.3	1.1±6.9	0.6
Femoral anteversion (degrees)	−0.1±7.6	−0.8±6.2	0.5
Femoral anterior offset (mm)	6.7±2.9	6.9±3.5	0.9

α acetabular cup inclination

Values are means and standard deviation

three in group 2 (3.1 %), and two in group 3 (2.1 %). All patients with groin pain were managed first with oral anti-inflammatory medications. After clinical research and imaging, iliopsoas conflict was diagnosed in six patients (2.3 % of the cohort and 40 % of groin pain cases). All were infiltrated, as mentioned above.

At one year and at last follow-up, groin pain persisted in seven patients (2.7 %). No groin pain emerged between six months and last follow-up. Groin pain was still statistically more frequent in group 1 ($p=0.04$). Five patients had groin pain in group 1 (6.6 %) with one patient in each of the other groups (1 % in two others groups). Groin pain was not correlated with cup size ($p=0.1$), but mean cup diameter was greater in the groin pain group (56.9 mm versus 54.7 mm in groin pain-free patients). Two of these groin pain cases presented persistent iliopsoas conflict (noted in six patients at six-month follow-up). A second infiltration was provided. In these patients, symptoms re-appeared at three and four months after second infiltration. One of them underwent psoas tenotomy, and the second was totally relieved by a third infiltration. Except for these cases, cause of groin pain remained unknown in the other five patients despite extensive evaluation.

Review revealed that two patients experienced groin pain with over-reamed acetabulum at six months but none at last follow-up. On the other hand, 55 patients without groin pain had an over reamed acetabulum (47 of 1 mm size and eight of 2 mm size). Radiologically, all implants appeared to be well

fixed. None manifested infection during follow-up. Whatever the follow-up, cup inclination was not related to groin pain (Table 3). Cup lateralisation means were higher in groin pain patients, but the differences were not statistically significant (Table 3).

Three patients manifested heterotopic ossifications [23]: one grade 1 (group 1), one grade 3 (group 1) and one grade 4 (group 2). None had groin pain. The grade 4 case was re-operated for arthrolysis and removal of heterotopic ossification. No dislocations and superficial or deep wound infections were evident among the 264 HRAs. No patients underwent revision surgery, except for psoas tenotomy.

At six months and at last follow-up, no statistically significant differences in clinical scores (MDP and HHS) were apparent in the three-implant groups. However, at one-year follow-up, mean OHS was significantly lower in group 1 (19.9 points) than in group 2 (15.3 points) and group 3 (14.3 points, $p=0.02$), and mean Devane score was lower in group 1 (3 versus 4.4 in group 2 and 4.1 in group 3, $p=0.01$) (Table 4).

Discussion

Development of modern bearing surfaces suitable for return to high-level activities has expanded the field of use and indication of hip prostheses [24–26]. HRA, with prosthetic femoral head diameter close to native diameter and high wear resistance (without the risk of head fracture), has become the implant of choice in young patients [2, 24]. The excellent hip function seen in resurfacing patients may be attributed to the nature of the resurfacing procedure on femoral head that conserves bone stock and mechanoreceptors, allowing close approximation to normal proximal femoral anatomy [27–29]. Precise biomechanical reconstruction after HRA aims at preserving abductor and extensor moment arm distances [30]. However, it appears that a high groin pain rate could occur after HRA and significantly affects clinical function [11].

Our study has several limitations. It was not a randomized, controlled trial designed to assess significant differences between resurfacing implant types. However, the same surgical

Table 4 Clinical scores at last follow-up of the three groups

Scoring system	Group 1	Group 2	Group 3	<i>p</i>
OHS ^a (points)	19.9±4.8 (12–47)	14.3±2.5 (12–24)	15.3±4.4 (12–35)	0.02
MDP ^b (points)	17.1±1.2 (13–18, 18)	17.3±1 (14–18, 18)	17.3±1.3 (12–18, 18)	0.9
HHS ^a (points)	94.1±5.6 (78–100)	96.8±5.2 (81–100)	96.1±7.9 (50–100)	0.3
Devane ^b (points)	3±0.8 (2–5)	4.4±0.85 (2–5)	4.1±0.8 (2–5)	0.01

OHS Oxford hip score, HHS Harris hip score, MDP Merle d'Aubigné-Postel score

^a Values are means and standard deviation, with range in parentheses^b Values are means, with range and median in parentheses

approach was taken systematically by one surgeon for all procedures and seemed to strongly limit per-operative bias. Follow-up was different according to each group, but groin pain occurred very early after the procedure and was stable on longer follow-up. Recent studies found groin pain to be more frequent after hip resurfacing than THA [6, 8, 9]. Bin Nasser et al. [6] and Bartelt et al. [9] observed 18 % each whereas Fowble et al. [31] reported 52 % pain after HRA (versus 80 % after THA) without precise location at two years of minimum follow-up. Lavigne et al. [11] noted 17.7 % and 15.2 % of groin pain cases at six and 12 months, respectively. Some of them could have been due to specific resurfacing techniques, e.g. impingement of the native femoral neck on the acetabulum [32], femoral neck fractures, femoral component collapse or biological reactions to metal ions or particles [9, 11]. Moreover, groin pain seems to have greater clinical impact on clinical function in HRA than in THA [14].

Our findings are quite different, with a 5.7 % groin pain rate at six months and 2.7 % at last follow-up. Bin Nasser et al. [6] obtained a higher rate, but just 10 % of their groin pain patients limited their activities or took analgesics. Bartelt et al. [9] reported a majority of mild pain cases, and we do not know their functional impact. Lavigne et al. [11] showed that the effect of groin pain on clinical function was greater after HRA than after THA, but 56 % of patients with groin pain did not take any treatment. The low groin pain rate in our series (2.7 %) probably derived from a specific surgical technique that was always followed. We systematically let bone overhang 2 or 3 mm over the cup to avoid iliopsoas impingement or conflict between the metal alloy of the cup and the anterior capsule [8, 33]. Minimally posterior capsulotomy was performed, with no anterior capsulotomy. Preservation of the anterior capsule resulted in the conservation of hip proprioceptors and appeared to dramatically decrease anterior post-operative hip pain [34]. With our specific surgical procedure, exposure for acetabulum preparation was sufficient for progressive anterior translation of the femoral head. Some authors noticed that, with a conventional posterior approach, forceful anterior translation may damage the rectus femoris tendon or the anterior superior acetabular wall, causing post-operative pain [32].

In our series, the residual groin pain rate could have been secondary to acetabular cup design. At six months, the groin pain rate differed significantly in the three groups with 13.1 % in group 1, 3.1 % in group 2, and 2.1 % in group 3. At last follow-up, groin pain incidence had decreased (6.6 %, 1 % and 1 %, respectively). It had a strong influence on the subjective results, with significantly higher OHS in group 1 than in other groups and lower activity assessed with the Devane scale. However, groin pain evolution appeared to show that it decreased with time and could be related to primary fixation according to cup design. The implanted cup

diameter seems not to be a major risk factor for groin pain since it is no longer significant at one year of follow-up.

The thick monoblock CoCr cup design may cause pain by transmitting peak load to the periacetabular area [11]. Moreover, bonding distribution induced by macrostructure design of the cup component could increase stresses on acetabular bone and are already shown to have a poor track record [35]. All cups from the three groups were systematically impacted by a 2-mm press fit (the true diameter of the reamer was 2 mm under the size of the cup). According to the cup design, the impaction of full metal alloy cups with external macrostructures with a hammer leads to potentially strong peripheral press fit. This assumption has to be confirmed by a rigorous review of component migration on serial X-rays or CT. With follow-up, it seems that healing of these microcracks culminated in milder groin pain but the residual rate was higher than with other designs. Indeed, the prominence of macrostructures designed for HRA cups seems to be recommended with caution because of difficulties in primary fixation and exposed to iliopsoas irritation.

It is important to note that comparison with Durom cups did not indicate poor results with this design. The poor results observed with Durom cups seem to be more frequent with large femoral head THA combination [36]. Berton et al. [37] determined that incomplete introduction of Durom fins into acetabular bone led to 35 % of gaps. These fins were at the origin of difficulties in primary fixation and play a role in secondary fixation failure. They seem to reduce bone-implant contact surface and impair secondary bone fixation. Femoral and acetabular bone loading appear better with HRA configuration, without strong rigidity induced by the association between thick metallic cups and stems.

Conclusion

The low groin pain rate in our prospective cohort was probably secondary to the specific surgical technique employed (with respect to the anterior capsule, minimal posterior capsulotomy, no gluteus maximus release from the linea aspera, and preventing cam effect by optimising anterior head to neck offset). With the same surgical procedure and the same surgical surgeon, residual groin pain seems to be correlated with cup design. Macrostructures on the external part of the cup appear to play a major, harmful role. Indeed, HRA cups with macrostructures seem to be worsened by poor primary fixation, which may engender unpredictable groin pain and drive us to recommend a careful survey of this component.

Conflict of interest No organization sponsored the research.

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