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Original article

High-impact sport after hip resurfacing: The Ironman triathlon

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ABSTRACT

Background: Returning to high-impact sport is an increasingly frequent functional demand following hip replacement. The literature, however, is sparse on the subject and nonexistent regarding triathlon. We therefore conducted a retrospective study of hip resurfacing in triathlon players, to determine: (1) whether it is possible to return to this kind of sport; (2) if so, whether it is possible to return to the same level; and (3) how a resurfaced hip behaves under these conditions.

Hypothesis: Hip resurfacing allows return to competition level in long-distance triathlon.

Material and methods: A single-center single-operator retrospective study included patients undergoing hip resurfacing with the Conserve Plus implant inserted through a posterolateral approach, who had ceased long-distance triathlon practice due to osteoarthritis of the hip. Fifty-one of the 1688 patients undergoing resurfacing during the inclusion period were long-distance triathlon players.

Results: The series comprised 48 patients: 51 implants; 43 male, 5 female; mean age, 44.8 years (range, 28.2–58.9 years). At a mean 4.7 years' follow-up (range, 2.2–7.6 years), all clinical scores showed significant improvement; Merle d'Aubigné and Harris scores rose respectively from 12.3 (5–16) and 42 (37–56) preoperatively to 17.5 (13–18) and 93.2 (73–100) ($P < 0.001$). There were no cases of dislocation or implant revision. Forty-five patients returned to sport (94%). Rates of return to swimming, cycling and running were respectively 38/48 (79%), 41/48 (85%) and 33/48 (69%). Preoperatively, all patients had taken part in at least 1 competition: 29 with distance = 70.3 km and 19 with distance = 140.6 km. At follow-up, 28 patients had taken part in an Ironman competition: 21 with distance = 70.3 km and 7 with distance = 140.6 km. Mean competition performance did not differ between pre and postoperative periods.

Discussion: Return-to-sport rates were good following hip resurfacing. Non-impact sports (swimming, cycling) predominated postoperatively, whereas the rate of impact sport (running) diminished. Return to competition-level sport (extreme triathlon) was possible for 28/48 patients (58%). Implant survival seemed unaffected by this high-impact sports activity at a mean 4.7 years' follow-up.

Level of evidence: IV, retrospective, non-controlled.

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1. Introduction

Historically, hip arthroplasty sought to meet the need to restore patient's functional autonomy and abolish pain. The "Millennium" generation, with their increasingly active lifestyle, have revolutionized these functional expectations. Patients now seek to recover optimal quality of life, with physical activity level in the foreground. The therapeutic challenge has thus progressed and

practice, implants and surgery have had to adapt. Minimally invasive techniques and fast-track management seek to meet these expectations [1]. Hip implants have likewise progressed: large-diameter heads to avoid dislocation, more resistant friction couples to minimize wear, optimized head-neck ratio in the femoral component to delay the cam effect and increase range of motion and shorter femoral stems to avoid thigh pain and conserve femoral bone stock [2].

Hip resurfacing aims to fulfill all these criteria:

- no dislocation;
- resistant friction bearing;
- conserved proprioception;
- no thigh pain [2].

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It is proposed to a very specific patient population: young active athletic patients with osteoarthritis. Return to sport after hip resurfacing is a reality, even for high-impact sports such as tennis, running and hockey [3–5]. In this category of impact sports, triathlon, combining swimming, cycling and running, is growing year after year [5]. The longest triathlon distance (the Ironman competition) is considered as an extreme challenge.

The literature on the subject is sparse, especially as regards patients' ability to take up or return to this type of sport. We therefore conducted a retrospective study of hip resurfacing in triathlon players, to determine:

- whether it is possible for them to resume this type of sport;
- and if so at what level;
- the behavior of a resurfaced hip under these conditions.

2. Material and method

2.1. Patients

A single-center single-operator retrospective study included patients operated on for hip resurfacing, having ceased triathlon practice due to osteoarthritis of the hip, between February 2009 and December 2013. Inclusion criteria involved having preoperatively performed at least one 70.3 (1.9 km swimming, 90 km cycling, 21.1 km running) or 140.6 Ironman triathlon (3.8 km swimming, 180 km cycling, 42.2 km running). During the inclusion period, the operator performed 1688 resurfacing procedures (1598 patients), 52 of which (49 patients) met the inclusion criteria. All patients filled out a dedicated questionnaire detailing their sports practice as overall weekly duration per type of sport and also competition results.

2.2. Methods

The resurfacing implant was the Conserve Plus (Wright Medical Technology, Arlington, TN, USA). The surgical technique consisted in a posterolateral approach without circumferential capsulotomy [6]. Immediate weight bearing was authorized. Fifteen rehabilitation sessions were performed and return to sport was left up to the patient.

2.3. Assessment

Clinical assessment at end of follow-up recorded Postel Merle d'Aubigné [7], Harris [8] and Oxford scores [9] and activity level on the UCLA scale [10]. Radiographic analysis was based on AP pelvic views assessing frontal cup position (inclination angle), onset of ossification following Brooker et al. [11], >3 mm radiolucency around the cup (according to DeLee and Charnley [12]) and the femoral component.

Biological analysis of chromium and cobalt metallic ions was performed on whole blood, using a high-resolution sector field inductively coupled plasma spectrometer (HR-SF-ICPMS), comparing preoperative and last follow-up assays. Detection limits were 0.1 µg/L for both ions [13]. Preoperative assays were missing for 3 of the 47 patients; 2 last follow-up assays were missing.

2.4. Statistics

Statistical analysis used SPSS software (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0, IBM Corp, Armonk, NY, USA). Tests were 2-tailed, with first-order risk set at 5%. Normality of distribution was checked graphically on histograms and by Shapiro–Wilk test. In case of significant deviation from normality without obvious transformation, non-parametric

Table 1

Progression between preoperative and last follow-up clinical scores (mean [range]).

	Preoperative	Follow-up	P
PMA score [7]	12.3 (5–16)	17.5 (13–18)	<0.0001
Mobility	4.7 (2–6)	5.9 (5–6)	<0.0001
Function	4.5 (3–6)	5.7 (4–6)	<0.0001
Pain	3.1 (2–4)	5.9 (4–6)	<0.0001
Harris score [8]	42 (37–56)	93.2 (73–100)	<0.0001
Oxford-12 score [9]	36 (23–48)	14.3 (12–25)	<0.001
UCLA score [10]	4.8 (3–9)	9 (2–10)	<0.001

tests were used. Associations between quantitative variables were assessed by Pearson and Spearman correlation coefficients. Inter-group comparisons used Student *t* test or analysis of variance for groups exceeding 30, or otherwise Mann–Whitney or Kruskal–Wallis test.

3. Results

Only 1 of the initial 49 patients declined to participate; the series thus comprised 48 patients: 51 procedures; 43 male, 5 female; mean age at surgery, 44.8 years (range, 28.2–58.9 years). Indications for resurfacing were osteoarthritis of the hip in all cases. Mean height was 1.77 m (range, 1.67–1.94 m) and mean weight 71.5 kg (range, 54–85 kg). Mean prosthetic femoral head diameter was 52.8 mm (range, 48–60 mm), for a median 52 mm. Mean follow-up was 4.7 years (range, 2.2–7.6 years).

Clinical scores showed systematic improvement (Table 1). Radiographic analysis found a mean cup inclination of 41.5° (range, 32–51°). One patient (with 2 procedures) showed Brooker 3 ossification. There were no cases of femoral or acetabular radiolucency.

Before symptom onset and at last follow-up, patients practiced respectively a mean 11 h39 mn (range, 8–15 h) and 12 h06 mn (range, 10–16 h) sport per week (Table 2): i.e., no significant difference. Cycling was the predominant sport, both preoperatively (5 h50 mn (range, 4–8 h)) and at follow-up (6 h55 mn (range, 4–11 h)). There was, however, a significant change in relative volumes, with a reduction of 1 h36mn (range, 1–5 h) in running ($P < 0.05$) and a significant increase of 1 h05 mn (range, 1–4 h) in cycling ($P < 0.05$) and of 1 h15 mn (range, 1–3) in swimming ($P < 0.05$) at last follow-up. Time to return to sport was shorter for non-impact sports (swimming and cycling: respectively 6.2 weeks [range, 3–12 weeks] and 5.4 weeks [range, 3–11 weeks]) than for running (16.1 weeks [range, 4–22 weeks]).

Forty-five of the 48 patients (94%) showed overall return to sport. The rates of return to swimming, cycling and running were respectively 38/48 (79%), 41/48 (85%) and 33/48 (69%). Preoperatively, all patients had taken part in at least 1 competition: 29 with 70.3 km and 19 with 140.6 km distance (Table 2). At follow-up, 28 patients (58%) had again taken part in an Ironman competition: 21 with 70.3 km and 7 with 140.6 km distance (Table 2). Six patients with 140.6 km distance preoperatively dropped to 70.3 km during follow-up. Mean performance was unchanged ($P = 0.4$; Table 2). Return to sport, whether overall or for each sport, showed no correlation with clinical scores (PMA, Harris), UCLA score, head diameter, weight or height.

At last follow-up, 6 of the 20 patients who had not resumed Ironman competitions had taken part in shorter (medium to short distance) triathlons, 8 practiced only non-impact sports (swimming, cycling) and 3 had ceased all sports activity (for reasons unrelated to surgery). Three other patients were unable to practice running due to groin pain, but were able to swim and cycle; they showed no ilio-psoas impingement or cobalt ion level elevation.

There was 1 case of early infection, requiring early lavage associated to 2 months' antibiotic therapy, without clinical impact at last follow-up. One hematoma was treated by surgical evacuation

Table 2
Progression in sports activity (mean [range]).

	Before onset of arthritic pain	Last follow-up	P
Type of competition	70.3 km: 29 patients 140.6 km: 19 patients	70.3 km: 21 patients 140.6 km: 7 patients	0.3 <0.001
Best competition time	70.3 km: 6 h 02 mn (4h 56–7 h 01) 140.6 km: 12 h 42 mn (10 h 02–15 h 47)	70.3 km: 6 h 24 mn (5 h 25–7 h 34) 140.6 km: 12 h 49 mn (11 h 11–15 h 21)	0.4
Weekly swimming	2 h 30 mn (1–4)	3h 45 mn (2–6)	<0.0001
Weekly cycling	5 h 50 mn (4–8)	6 h 55 mn (4–11)	<0.0001
Weekly running	3 h 30 mn (2–6)	1 h 54 mn (1–6)	<0.0001
Overall weekly volume	11 h 39 mn (8–15)	12 h 06 mn (10–16)	0.17

at week 2. There were no implant revisions at a mean 4.7 years' follow-up.

Metallic ion assessment found significant elevation of cobalt and chromium, from respectively 0.4 µg/L (range, 0.01–0.89) and 0.4 µg/L (range, 0.1–0.9) preoperatively to 1.3 µg/L (range, 0.5–4.4) and 1.4 µg/L (range, 0.35–4.9) at follow-up ($P < 0.0001$). The titanium level was 3.8 µg/L (range, 2.7–6.7) preoperatively and 3.7 µg/L (range, 2.1–8.9) at follow-up ($P = 0.7$). There was no correlation between chromium and cobalt ion levels and cup inclination ($P = 0.5$), prosthetic head diameter ($P = 0.4$), UCLA score ($P = 0.6$) or PMA score ($P = 0.7$).

4. Discussion

Return to sport after hip arthroplasty is an increasingly frequent patient expectation. At the same time, present-day changes in sport activity witness a rise in extreme activities. Triathlon is one of these, and return to triathlon after prosthetic surgery has never been studied in the literature. The present series showed an excellent rate of return to sport following hip resurfacing. Return to competitive sport was possible for almost 60% of patients. Implant survival seemed unaffected at a mean 4.7 years' follow-up.

The present study showed several limitations. Firstly, it was not prospective; however, only 1 patient declined to participate. Moreover, it seems difficult to follow return to training and competition prospectively: time to resumption can be quite long and varies between sports. Likewise, return to competitive sport can be affected by numerous factors: physical, financial and psychological. Secondly, the series may seem small; this is nevertheless the only study on the topic and the number of participants in these extreme triathlon formats is very small in the general population and even more so in the population of arthroplasty patients.

Resumption following hip resurfacing has been studied for certain sports. Sandiford et al. [14] reported resumption at the previous level of practice at 3 months, with no significant difference in surgical revision rates compared to a sedentary population. Return to running after hip resurfacing showed no difference in practice time before and after surgery, with no revision surgery [4]. High-impact sport could be resumed by 94% of patients by 4 months [5]. A prospective randomized study [3] comparing return to sport after hip resurfacing and total hip replacement found a significant difference in favor of resurfacing for high- to moderate-impact sports, with no difference in revision rates. Return to sport after hip arthroplasty depends on several factors. Prosthetic femoral head diameter identical to the native diameter prevents instability and functional limitation [3]. Reacquisition of sport technique correlates directly with range of motion of the joint in question. Likewise, conserved joint proprioception is essential to athletic movement. Stabilometric analysis of dynamic motor function in resurfacing patients showed identical results to those of non-operated subjects, whereas results were significantly poorer with total hip replacement [15,16]. The absence of any femoral shaft trepanation or

prosthetic stem avoids the risk of thigh pain [17]. Moreover, the absence of femoral shaft rigidity guarantees conservation of bone elasticity in the shaft, with better stress transfer [18]. This point is crucial for return to impact sports such as running. Finally, recovery of joint biomechanics is essential, the two main factors being respect of femoral offset (abductor apparatus lever arm) and limb-length [19,20]. Biomechanical parameters are almost automatically restored, since bone resection thickness matches that of the metal component [20,21].

The present study also showed that patients increased their practice of non-impact sports (cycling and swimming) and reduced impact sport (running). It is difficult to analyze these findings, but it seems to be a matter of personal choice, patients wishing to spare their implant and remaining joint capacity. Ollivier et al. [22] reported that patients feared early wear in resuming sport after hip arthroplasty. With conventional total hip replacement, Schmalzried et al. [23] found a strong correlation between activity level and wear; but these findings need reconsidering since the introduction of more resistant friction bearing. Cross-linked polyethylene shows significantly less wear than conventional polyethylene, even in active patients [24]. Ceramic-on-ceramic bearing drastically reduces wear and osteolysis, although incurring specific complications: head or insert fracture, onset of squeaking [25]. Metal-on-metal bearing also generate less wear debris, but with a risk of side effects in the form of adverse reaction to metal debris [26,27]. There were no such adverse events in the present series, despite intensive high-impact sport activity. Likewise, metallic ion levels were very low and well below international thresholds: 3 µg/L for unilateral and 7 µg/L for bilateral hip resurfacing [27]. The large femoral head diameter (53 mm) and optimal mean cup inclination of 41.5°, with none exceeding 51°, partly account for this low rate of ion release compared to other implant surgeries, such as modular neck total hip replacement, knee replacement or spine surgery [28–30].

At a mean 4.7 years' follow-up, there were no cases of implant dislocation or revision. The 100% implant survival rate was very satisfactory, in a population of young athletic patients, for whom the risks of wear, osteolysis and implant loosening are theoretically high. In the Swedish registry [31], 5-year survival of total hip replacement in under-50 year-olds was only 95.7%. This was confirmed in the Australian registry of 266,645 hip arthroplasties, with a 10-year revision rate of 6.6% for total hip replacement, but 8.8% (range, 7.9–9.0%) in under-55 year-olds [32].

5. Conclusion

Return to sport after hip arthroplasty is an increasingly common functional demand. Extreme sports such as long-distance triathlon constitute a major therapeutic challenge. Resurfacing seems to fulfill the charge-book for this very specific group of patients. Most of the present series were able to resume competitive sport and/or continue with very intensive practice. There were no

revision surgeries or dislocations, although follow-up was short (less than 5 years). The present results seem better than those reported elsewhere, but our cohort needs to be followed up over the long-term. The long-term impact of sports activities on implant fixation is poorly known, requiring rigorous longer-term analysis.

Disclosure of interest

J. Girard is a consultant for Microport and Smith & Nephew.

The authors A. Lons, T. Pommepuy, R. Isida, K. Benad, S. Putman declare that they have no competing interest.

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