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How to cite

FAVRE, Thibault et al. Comparison of Results of Total Hip Arthroplasty in Patients Under 50 Years Who Had Osteonecrosis of the Femoral Head or Osteoarthritis : A Propensity-Matched Cohort Study From the Geneva Arthroplasty Registry With a Mean 12-Year Follow-Up. In: The Journal of arthroplasty, 2025. doi: 10.1016/j.arth.2025.05.107

This publication URL: https://archive-ouverte.unige.ch/unige:187408
Publication DOI: 10.1016/j.arth.2025.05.107

The Journal of Arthroplasty xxx (2025) 1–7

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Comparison of Results of Total Hip Arthroplasty in Patients Under 50 Years Who Had Osteonecrosis of the Femoral Head or Osteoarthritis: A Propensity-Matched Cohort Study From the Geneva Arthroplasty Registry With a Mean 12-Year Follow-Up

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ARTICLE INFO

Article history:
Received 6 January 2025
Received in revised form
26 May 2025
Accepted 27 May 2025
Available online xxx

Keywords:
total hip arthroplasty
osteonecrosis
registry
under 50 years
propensity score

ABSTRACT

Background: Patients who have osteonecrosis (ON) of the femoral head often require total hip arthroplasty (THA), usually before the age of 50 years. The ON population appears to have inferior outcomes compared to patients who have received THA for other conditions. The aim of this study was: (1) to compare the overall survival rate; and (2) to evaluate five- and 10-year clinical outcomes of primary THA in patients under 50 years of age who had ON or osteoarthritis (OA) using the Geneva Arthroplasty Registry. Also, we tried to identify risk factors for THA failure in patients under 50 years of age.

Methods: Patients under 50 years of age who underwent primary THA for ON or OA between 1996 and 2021 were identified. After matching the two groups by propensity score, 290 patients were finally included: 145 in each group. The mean age of the population was 43 years (range, 19 to 49), 28.3% (82 of 290) of the patients were women, and the mean body mass index was 26.3 (range, 16.7 to 46.0).

Results: The overall survival rate in the OA group was 79.8% [71.0 to 89.8] and 83.4% [76.0 to 91.6] in the ONA group, without significant difference ($P = 0.68$) at 20 years. Regarding clinical outcomes, we observed a difference for the pre–post delta of the pain subscale of the Harris hip score, which was higher in the OA compared to the ONA group (25.6 ± 11.6 versus 18.7 ± 14.1, $P = 0.01$) at 5 years postoperative. At 10 years, the pre–post delta of the Short-Form 12 physical score was higher in the OA group compared to the ON (13.9 ± 11.4 versus 5.3 ± 11.3), $P = 0.05$. Being older (hazard ratio = 0.92 [0.87 to 0.97], $P < 0.01$) or using a cementless cup (hazard ratio = 0.20 [0.05 to 0.87], $P = 0.03$) were identified as protective factors in the multivariate analyses.

Conclusions: In terms of survival, it's reasonable to propose a THA to patients under 50 years of age suffering from ON, which will improve their quality of life and function in the long term.

Level of Evidence: Level III, Case-Control Studies.

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.arth.2025.05.107.

Ethical approval and informed consent statements: approved end informed.

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https://doi.org/10.1016/j.arth.2025.05.107

Osteonecrosis (ON) has an incidence of 1.4 to 3.0 per 100,000 in the United Kingdom population [1] and is more common in the femoral head. The mean age of onset is 47 years, with a predominance of men 3:1 [2]. Corticosteroid use, alcoholism, and trauma remain the most common causes of the condition [2–5].

There are several medical or surgical options for the treatment of ON [1]. For precollapse lesions of the femoral head, several surgical techniques have been described, such as core decompression, bone grafting, or osteotomy. For terminal lesions or failure of the head-sparing techniques, total hip arthroplasty (THA) is almost the only answer. Canadian, Swedish, and Australian registries have shown that 2.8 to 6.0% of all THAs are used to treat ON. (4).

The prevalence of ON is increasing worldwide [6–8] and particularly in patients under 50 years of all age groups due to corticosteroid use [9,10]. There is a real challenge to treating patients of a younger age with THA. Indeed, the lifetime of the THA needs to match the life expectancy of this osteonecrosis population. Furthermore, these young patients have a higher activity level, which may increase the revision rate. Also, the ON population seems to have inferior outcomes compared to patients who received THA for other conditions [11].

A recent study looked at the effect of age in the ON THA group and found that medical complications increased with age, and surgical complications decreased [12]. The ON patients requiring THA are generally under 50 years of age, and it is important to know whether it is appropriate to offer them arthroplasty or not. However, to our knowledge, no study has compared the long-term outcomes of THA in patients under 50 years of age operated on for ON with those operated on for osteoarthritis (OA).

The aims of this study were: (1) to compare the overall survival rate and the survival rate of revision for any cause for septic and aseptic loosening of primary THA in patients under 50 years of age who had ON or OA using the Geneva Arthroplasty Registry (GAR) database; (2) to determine clinical and patient-reported outcomes based on the Harris Hip Score (HHS), Merle d'Aubigné (MA) score, the Short-Form 12 (SF-12) mental and physical score, and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain and functional score; and (3) to identify risk factors for THA failure in patients under 50 years of age.

Methods

Patients

The Geneva Arthroplasty Registry (GAR) has recorded patient and surgical data for THA performed at the Geneva University Hospital in Switzerland since 1996. Patients under 50 years of age who underwent primary THA for ONA or OA between March 1, 1996, and December 31, 2021, were identified from the GAR. We included all etiologies of ON and OA, all Ficat and Arlet Classification scores, patients who had previous hip surgery, and all types of stems, cups, and bearings. To ensure an accurate etiological classification, the surgeon could select among OA, ON, dysplasia, arthritis, posttraumatic causes, and other indications. Moreover, all surgeons in our institution were trained to complete the registry with the highest possible accuracy. Exclusion criteria were oncological history, inflammatory arthropathy, and total hip revision surgeries. During the study period, among the 8,971 primary THAs recorded in the GAR, 427 patients (4.8%) met our inclusion criteria: 214 in the OA group and 213 in the ON group. After matching the two groups by propensity score, 290 patients were finally included: 145 in each group. The mean age of the population was 43 years (range, 19 to 49); 28.3% (82 of 290) of the patients were women, who had a mean body mass index (BMI) of 26.3 (range, 16.7 to 46.0). The associated risk factors for osteonecrosis were idiopathic in 33.8% (49 of 145), alcohol in 28.3% (41 of 145), corticosteroid use in 8.9% (13 of 145), posttraumatic in 7.6% (11 of 145), HIV in 3.4% (five of 145), sickle cell disease in 2.8% (four of 145), and other causes in 15.2% (22 of 145). There were two patients in the osteoarthritis (OA) group who had a history of arthroscopy (1.4%, two of 145). In addition, four patients (2.8%, four of 145) in the OA group had undergone previous surgeries, including three childhood osteotomies (2.1%, three of 145) and one case of head drilling (0.7%, one of 145). There was one patient who required the removal of a dynamic hip screw during hip arthroplasty, but none of them required bone grafting or the use of a revision acetabular or femoral implant. Demographic data for the two groups are shown in Table 1.

Surgical Data

There were four surgical approaches used: direct anterior in 56.2% (163 of 290), direct lateral in 34.1% (99 of 290), posterior in 8.6% (25 of 290), and transtrochanteric in 1.0% (three of 290). There were five types of bearing surfaces used: ceramic-on-ceramic in 18.6% (54 of 290), ceramic-on-polyethylene in 10.0% (29 of 290), ceramic-on-highly crosslinked polyethylene in 45.5% (132 of 290), metal-on-metal in 24.1% (70 of 290), and metal-on-polyethylene in 1.7% (five of 290). Femoral stems were cemented in 26.9% (78 of 290), and acetabular cups were cemented in 2.8% (eight of 290). Surgical data in the two groups are shown in Table 2.

Variables

Demographic data, including age, sex, BMI, and American Society of Anesthesiologists (ASA) physical status, were recorded for each patient on the day of surgery. Clinical follow-up of each patient was recorded in the GAR at one, five, and 10 years after surgery. At each endpoint, functional scores (HHS, MA, SF-12 mental and physical score, WOMAC pain and functional score, physical examination, and radiographic evaluation) were performed. Data on aseptic and septic loosening, surgical revision and reoperation, and surgical complications were available for all patients.

Outcomes

Our primary outcome was the comparison of overall primary THA survival between the ONA group and the OA group at final follow-up. The secondary outcomes were survival rates for revision of any cause, septic and aseptic loosening. We also evaluated long-term clinical outcomes. Also, we tried to identify risk factors for THA failure in patients under 50 years of age.

Table 1
Demographic Data.

Parameters	Values	145	OA Group	145	ONA Group	*P*-Value
Age (years)		145	43.84 (4.79)	145	43.28 (5.3)	0.46
BMI		145	26.62 (4.96)	145	26.06 (4.77)	0.49
Sex (%)	Women	41	28.3	41	28.3	1.00
	Men	104	71.7	104	71.7	
ASA		145	1.90 (0.54)	145	1.91 (0.55)	0.84
Follow up in years		145	12.38 (6.83)	145	12.94 (6.15)	0.32

OA, osteoarthritis; ON; osteonecrosis; BMI, body mass index, ASA, American Society of Anesthesiologists.

Table 2
Surgical Data.

Parameters	Values	145	OA Group (%)	145	ON Group (%)	*P*-Value
Surgical approach	Direct anterior approach	93	64.1	70	48.3	**0.003**
	Posterior approach	8	5.5	17	11.7	
	Direct lateral approach	41	28.3	58	40	
	Transtrochanteric	3	2.1	0	0	
Type of bearing	Ceramic-on-ceramic	31	21.4	23	15.9	0.43
	Ceramic-on-polyethylene	14	9.7	15	10.3	
	HXL	69	47.6	63	43.4	
	Metal-on-metal	29	20	41	28.3	
	Metal-on-polyethylene	2	1.4	3	2.1	
Type of fixation	Cemented THA	1	0.7	7	4.8	**0.011**
	Hybrid fixation THA	28	19.3	42	29	
	Cementless THA	116	80	96	66.2	

P value in bold indicate statistically significant differences ($P < 0.05$).
OA, osteoarthritis; ONA, aseptic osteonecrosis, HXL; highly crosslinked; THA, total hip arthroplasty.

Data Analyses

To match the two groups and limit the impact of external factors as well as any selection bias, propensity score matching was used. The propensity score was calculated by considering the patient's age at the time of surgery, sex of the patient, BMI, ASA score, and the time of follow-up. Each patient who underwent a primary THA for ON was matched with a patient who underwent THA for OA on a 1:1 basis. Matching was performed with a logit scale using a 0.3 caliper. Frequencies and percentages were used to describe discrete variables; continuous variables were described using means and standard deviations. For comparative analyses, Fisher's exact tests were used for percentages and the Wilcoxon tests for continuous variables. Kaplan–Meier analysis was used to analyze the survival rate of failure, defined as reintervention for any cause, considering revisions and other articulating operations (osteosynthesis, hematoma drainage) at the last follow-up. The association of risk factors with failure rate was evaluated using univariate Cox proportional hazards regression models. Hazard ratios (HR) are reported with the 95% confidence interval. $P \leq 0.05$ was considered to be significant for a power of 80% and an alpha risk of 5%. The R software (version 3.5.0) was used to perform statistical analyses (https://www.r-project).

Results

Survival Analyses

The overall survival rate in our series of primary THA under 50 years of age was 81.8% [76.0 to 88.0] at 20 years.

In the OA group, THA failure was observed in 12.4% (18 of 145): 13 cases had aseptic loosening, one case had periprosthetic joint infection, one case had instability, and three cases were revised for other reasons. Overall survival rate in this group was 95.0% [91.5 to 98.7] at 5 years, 88.8% [83.0 to 94.9] at 10 years, 82.4% [74.6 to 91.0] at 15 years, and 79.8% [71.0 to 89.8] at 20 years.

In the ON group, 11.7% (17 of 145) of THAs failed: ten for aseptic loosening (10 of 17), two for periprosthetic joint infection, two for periprosthetic fracture, one for instability, one for hematoma, and one for other reasons. Overall survival rate in this group was 94.3% [90.6 to 98.2] at 5 years, 88.5% [82.8 to 94.5] at 10 years, 85.2% [78.3 to 92.6] at 15 years, and 83.4% [76.0 to 91.6] at 20 years. There was no significant difference between these two groups ($P = 0.68$, Figure 1).

Regarding revision for any cause, no significant difference was observed between groups ($P = 0.43$, Figure 2), with a survival rate at 20 years of 79.9% [71.1 to 89.8] for the OA group and 84.2% [76.6 to 92.4] for the ON group.

Regarding aseptic loosening, no significant difference was observed between groups ($P = 0.40$, Figure 3), with a survival rate at 20 years of 83.8% [75.1 to 93.4] for the OA group and 89.9% [83.9 to 96.3] for the ON group.

For septic loosening, no significant difference was observed between groups ($P = 0.61$, Figure 4), with a 20-year survival rate of 98.8% [96.4 to 100.0] for the OA group and 98.1% [95.4 to 100.0] for the ON group.

Clinical Outcomes

At 5 years postoperatively, the OA compared to the ON group had higher HHS pain subscale (39.3 ± 9.4 versus 35.5 ± 9.7, $P < 0.01$), HHS (92.5 ± 12.4 versus 85.1 ± 16.8, $P < 0.01$), MA (16.5 ± 1.8 versus 15.6 ± 2.1, $P = 0.03$), and SF-12 mental scores (45.1 ± 18.8 versus 40.7 ± 11.0, $P = 0.04$). This difference was still observed for the delta between pre- and postoperative scores on the HHS pain subscale: (25.6 ± 11.6 versus 18.7 ± 14.1, $P < 0.01$) at 5 years.

At 10 years postoperatively, the OA group compared to the ON group had higher SF-12 physical scores (44.4 ± 10.6 versus 35.8 ± 10.2, $P = 0.01$). This difference was still observed for pre–post delta of SF-12 physical scores (13.9 ± 11.4 versus 5.3 ± 11.3, $P = 0.05$). Moreover, WOMAC pain and function scores tended to be higher in the OA group (77.7 ± 24.8 versus 67.5 ± 25.1, $P = 0.08$, and 76.4 ± 25.2 versus 63.5 ± 26.7, $P = 0.07$) (Table 3).

Risk Factors

Univariate analysis included age at the surgery, sex, BMI, ASA score, surgical approaches used, type of bearing, stem fixation, and cup fixation. Being older (HR = 0.93 [0.88 to 0.99], $P = 0.01$) or using a cementless cup (HR = 0.19 [0.06 to 0.61], $P < 0.01$) were protective factors. Use of metal-on-polyethylene (HR = 8.20 [1.13 to 59.25], $P = 0.04$) was a risk factor (Table 4). Multivariate analyses included age at surgery and cup fixation. Being older (HR = 0.92 [0.87 to 0.97], $P < 0.01$) or using a cementless cup (HR = 0.20 [0.05 to 0.87], $P = 0.03$) were still protective factors.

Discussion

The number of THAs per year is steadily increasing, and projections for 2050 are staggering worldwide [13,14]. The number of patients suffering from ON is increasing, especially in the population under 50 years of age [9,10]. The aim of our study was to evaluate whether it is safe to propose THA and to evaluate the

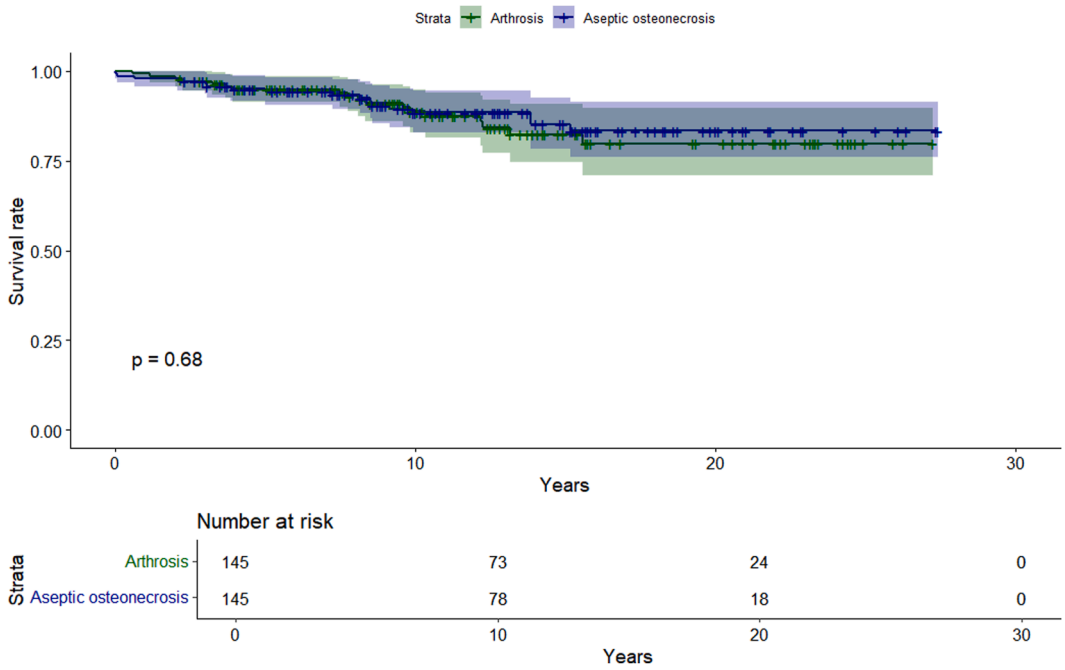

Figure 1. Comparison of overall survival rate between ON and OA THA. ONA, aseptic osteonecrosis; OA, osteoarthritis; THA, total hip arthroplasty.

long-term clinical outcomes in this population compared to the osteoarthritic population. We found no difference between the groups in terms of long-term survival and complication rates, but the OA group seems to have better clinical outcomes at five and 10 years. It seems reasonable to propose THA to patients under 50 years of age suffering from ON, which will improve five and 10 years of quality of life and function.

No Difference in Survival Rate and Complications Between Osteoarthritis and Osteonecrosis

We found, in our series, an overall survival rate of 81.8% [76.0 to 88.0] at 20 years. In a meta-analysis published in 2019, Evans et al. [15] reported a similar survival rate of THA at 20 years (with no distinction between etiology and bearing surfaces) of 78.8% [77.8 to 77.9] for 44 case series and 78.9% [77.9 to 80.0] for joint registries.

To our knowledge, the present study is one of the few to provide long-term results of THA performed for ON in young patients compared to OA. We found no significant difference in overall survival between the two groups. The survival curves (Figure 1) were very similar up to 10 years (ON group: 88.5% [82.8 to 94.5] versus OA group: 88.8% [83.0 to 94.9]), and it seemed to be better in the ON group after 10 years (at 20 years: ON group: 83.4% [76.0 to 91.6] versus OA group: 79.8% [71.0 to 89.8]). These results are in accordance with the international literature. Bergh et al. [16]

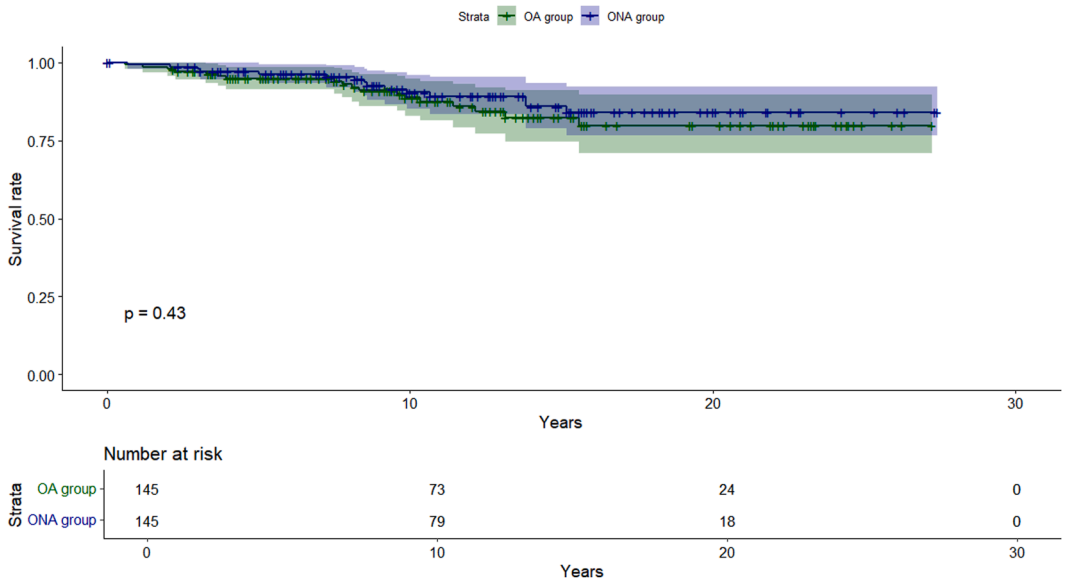

Figure 2. Comparison of revision rate between ONA and OA THA. ONA, aseptic osteonecrosis; OA, osteoarthritis; THA, total hip arthroplasty.

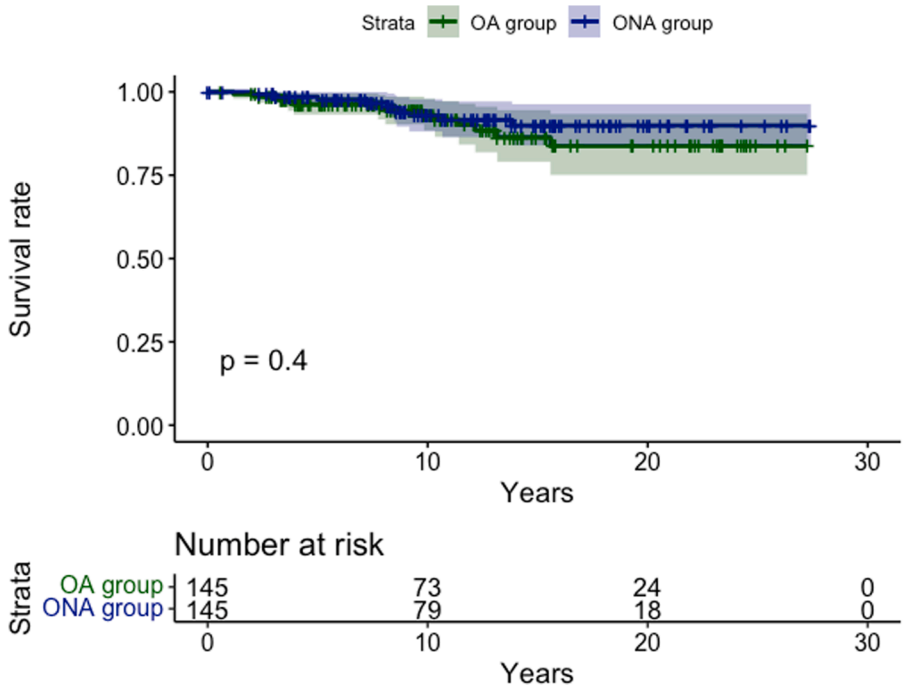

Figure 3. Comparison of aseptic loosening rate between ONA and OA THA. ONA, aseptic osteonecrosis; OA, osteoarthritis; THA, total hip arthroplasty.

showed a risk ratio of 1.13 [0.97 to 1.31] at 2 years of follow-up comparing OA with ON in patients under 50 years of age with no significant difference ($P = 0.1$). Ancelin et al. [17] compared ON and OA groups for metal-on-metal THA at 10-year follow-up. They found similar survival rates in both groups. This trend seems to be confirmed by other studies by Min et al. [18] and Kim et al. [11].

Only Salman et al. [19] found that the odds of revision were 1.58 times higher in the ON group than in the OA group. However, this meta-analysis did not stratify by age, which may influence survival, as shown in the study by Zhang et al. [12] Indeed, the number of comorbidities may increase with age. Sicker patients may have less demand for physical activity and therefore less wear of the implants.

Of the main reasons for revision described in the literature, one is prosthesis dislocation. In our study, 0.7% (two of 290) had a revision for instability: 5.9% in the ON group and 5.6% in the OA

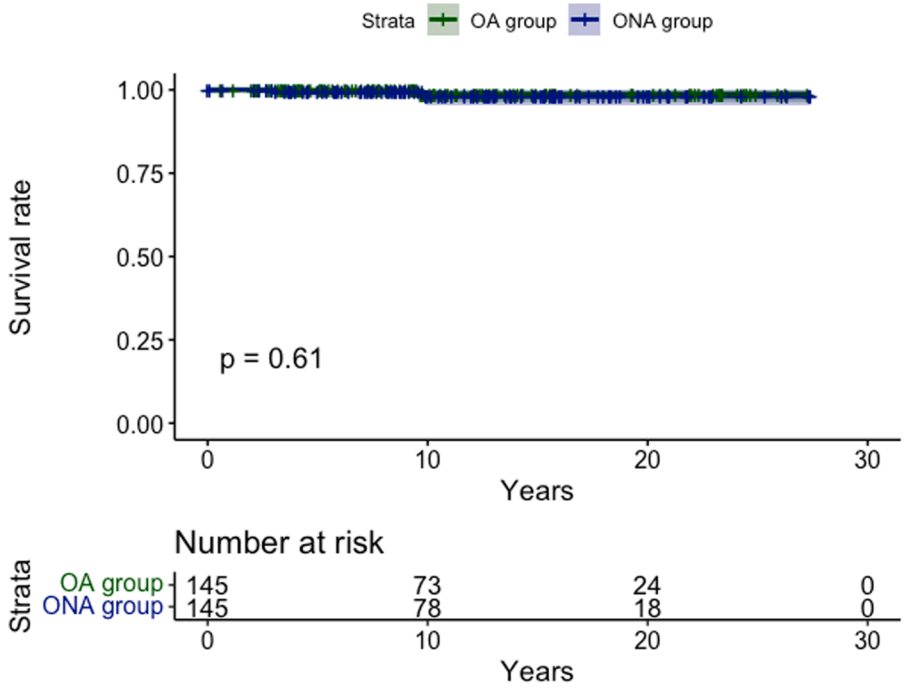

Figure 4. Comparison of septic loosening rate between ONA and OA THA. ONA, aseptic osteonecrosis; OA, osteoarthritis; THA, total hip arthroplasty.

Table 3
Clinical Outcomes.

Parameters	n	OA Group	n	ON Group	*P*-Value
Pain subscale of HHS					
Preoperative	122	14.3 (7.3)	111	14.5 (8.7)	0.48
5 years PO	73	39.3 (9.4)	52	35.5 (9.7)	**<0.01**
10 years PO	35	38.5 (9.2)	30	36.8 (9.2)	0.11
HHS					
Preoperative	92	50.8 (12.8)	93	45.9 (15.2)	**0.02**
5 years PO	72	92.5 (12.4)	52	85.1 (16.8)	**<0.01**
10 years PO	34	90.1 (13.3)	29	86.0 (13.5)	0.08
MA score					
Preoperative	25	11.1 (1.8)	18	11.4 (2.7)	0.61
5 years PO	63	16.5 (1.8)	50	15.6 (2.1)	**0.03**
10 years PO	32	16.3 (1.8)	27	15.6 (2.1)	0.14
SF-12 mental score					
Preoperative	85	42.7 (10.5)	70	36.9 (9.8)	**<0.01**
5 years PO	65	45.1 (11.8)	42	40.7 (11.0)	**0.04**
10 years PO	35	47.4 (9.4)	22	44.3 (10.1)	0.21
SF-12 physical score					
Preoperative	85	33.4 (7.0)	70	32.2 (17.5)	0.24
5 years PO	65	43.3 (11.0)	42	39.5 (10.7)	0.06
10 years PO	35	44.4 (10.6)	22	35.8 (10.2)	**0.01**
Pain subscale of WOMAC					
Preoperative	87	37.0 (17.3)	72	35.8 (17.7)	0.93
5 years PO	66	71.7 (29.5)	43	68.0 (24.3)	0.26
10 years PO	35	77.7 (24.8)	22	67.5 (25.1)	0.08
Function subscale of WOMAC					
Preoperative	85	40.0 (17.6)	71	36.2 (16.9)	0.48
5 years PO	65	73.3 (28.1)	43	68.4 (24.4)	0.23
10 years PO	35	76.4 (25.2)	22	63.5 (26.7)	0.07

P value in bold indicate statistically significant differences ($P < 0.05$).
PO, postoperative; OA, osteoarthritis; ON, osteonecrosis; SF-12, Short-Form 12; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; MA, Merle d'Aubigne; HHS, Harris Hip Score.

Table 4
Risk Factor of Failure for THA <50 years Old.

Characteristic	HR	95% CI	*P*-Value
Age	0.93	0.88; 0.99	**0.01**
BMI	1.00	0.94; 1.1	0.89
Sex			
Women	-	-	
Men	0.91	0.45; 1.86	0.80
ASA			
1 to 2	-	-	
3 to 4	1.06	0.32; 3.47	0.92
Surgical approaches	1.09	0.88, 1.36	0.42
Direct anterior approach	-	-	
Direct lateral approach	1.43	0.65; 3.15	0.37
Posterior approach	2.80	0.96; 8.13	0.06
Transtrochanteric	2.98	0.38; 23.38	0.30
Type of bearing			
Ceramic-on-ceramic	-	-	
Ceramic-on-polyethylene	1.23	0.22; 7.06	0.81
Ceramic-on-polyethylene HXL	1.15	0.25; 5.36	0.85
Metal-on-metal	2.40	0.52; 10.74	0.26
Metal-on-polyethylene	8.20	1.13; 59.25	**0.04**
Stem fixation			
Cemented	-	-	
Cementless	0.69	0.35; 1.37	0.30
Cup fixation			
Cemented	-	-	
Cementless	0.19	0.06; 0.61	**<0.01**

P value in bold indicate statistically significant differences ($P < 0.05$).
HR, hazard ratio, CI, confidence interval, BMI, body mass index, ASA, American Society of Anesthesiologists, HXL, highly crosslinked.

group of all revisions were due to dislocation. Bryan et al. [20] found a 4.2% dislocation rate leading to revision in their cohort of patients younger than 50 years of age, with 22% of ON cases. They explained this high number by a higher capsular laxity in the ON group [11,19]. The differences between the two studies may be explained by the surgical approaches used. They used the posterior approach in 40.7% of their cases, whereas in our study, we only performed the posterior approach in 8.6%.

In our study, no difference was found in the septic loosening rate between the OA and ON groups. This result is contradictory to the literature. Indeed, the meta-analysis performed by Ren et al. [21] found that ON is a risk factor for periprosthetic infection. This difference between our results and the international literature could be explained by a lack of power in our series for this outcome. We observed three periprosthetic joint infections (1.0%, three of 290): one in the OA group and two in the ON group.

Lower Pain and Functional Scores in Osteonecrosis

In terms of functional scores, there was mainly a significant difference between the ON and OA groups up to 5 years postoperatively. This trend seems to continue later without significant difference, probably due to a lack of power. These results are in contradiction to the data described in the literature. In their systematic review, Salman et al. [19] found no difference between the ON and OA groups for HHS (reported by six observational studies at different follow-ups). Ancelin et al. [17] found the lack of difference between the two groups for the MA score at the last follow-up. In this study, the authors did not report the sample size of the MA analyzed, and the range of the last follow-up was large. Interestingly, our group of ON patients had significantly lower clinical scores up to 5 years, which did not seem to be related to pain but rather to functional limitation. If we focus on the etiologies of the osteonecrosis group (alcohol, corticosteroid use, human immunodeficiency virus), we can assume that these patients have less physical capacity because of their comorbidities, which have an impact on the function scores at five and 10 years (Table 3).

Risk Factors for Failure

In our study, being younger and having a cemented cup were risk factors for failure. The influence of age has been discussed and is well demonstrated in the literature [12,22].

Acetabular cups were cemented in 4.8% of the patients of the ON group (seven of 145) and in 0.7% of the OA group (one of 145). In a systematic review, Johannson et al. [23] showed a clear reduction in the risk of loosening after 1990, as 89% of ON prostheses were cemented before this date. Bedard et al. [24] compared cemented and uncemented arthroplasty with a 10-year follow-up and showed a much lower revision rate in the uncemented group. In the present study, the metal-polyethylene bearing was identified as a risk factor in the univariate analysis, but not in the multivariate analysis. Questions remain regarding the choice of the optimal bearing couple in patients under 50 years of age. Ceramic-on-ceramic and the ceramic-on-highly crosslinked polyethylene bearings have been suggested in this population, with interesting results at 20 years [25,26]. However, in our department, most surgeons share a similar approach regarding the choice of the bearing surface, so the available data are insufficient to explore this aspect in greater detail.

Potential Limitations

Our study has several potential limitations. This research is a case–control study using a prospective institutional arthroplasty registry. It is not a randomized controlled trial. However, we

obtained two comparable groups for age, sex, BMI, ASA score, and time of follow-up using propensity score matching. It can therefore be considered a pseudo-randomized trial. Another limitation is that the number of revisions was relatively low; and thus, the difference in survival observed between the two groups might be clinically relevant, but not statistically significant. Also, we had a relatively high data loss in the medium to long term for clinical outcomes. However, this is one of the few studies to report clinical outcomes for THA in patients under 50 years of age who had ON at 10 years and to compare them to patients operated on for OA. Furthermore, there was no data loss for survival outcomes.

Conclusions

To our knowledge, this study is the first to compare long-term outcomes in patients under 50 years of age who have undergone THA for osteonecrosis or osteoarthritis. In terms of survival, it is reasonable to propose THA to patients under 50 years suffering from ON, which will improve their quality of life and function in the long term. However, the longer-term functional results will not be as good as those of THA for osteoarthritis.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

Use of ChatGPT to help to ensure the translation from French to English.

CRediT authorship contribution statement

Thibault Favre: Writing – original draft, Investigation, Data curation. **Pierre-Alban Bouché:** Writing – original draft, Methodology, Formal analysis. **Matthieu Zingg:** Writing – review & editing, Validation, Data curation. **Morgan Gauthier:** Writing – review & editing, Investigation. **Anne Lübbeke:** Writing – review & editing, Supervision, Formal analysis. **Didier Hannouche:** Writing – original draft, Supervision, Methodology, Conceptualization.

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