Orthopaedics & Traumatology: Surgery & Research 105 (2019) 1251–1256

Contents lists available at ScienceDirect

Orthopaedics & Traumatology: Surgery & Research

journal homepage: www.elsevier.com

Original article

What are the influencing factors on hip and knee arthroplasty survival? Prospective cohort study on 63619 arthroplasties☆

Bertrand Boyer[a,b,*], Barbara Bordini[b], Dalila Caputo[b], Thomas Neri[c], Susanna Stea[b], Aldo Toni[b]

[a] Inserm, U1059, 42055 St-Étienne, France
[b] Laboratorio di Tecnologia Medica, Istituto Ortopedico Rizzoli, Via di Barbiano, 1/10, 40136 Bologna, Italy
[c] Laboratoire interuniversitaire de biologie de la motricité (LIBM), CHU de Saint-Étienne, 42055 St-Étienne, France

ARTICLE INFO

Article history:
Received 10 October 2018
Accepted 26 July 2019

Keywords:
Arthroplasty survival
Registry
Hip
Knee
BMI
Gender
Diabetes

ABSTRACT

Background: Body mass index is used by the World Health Organization to classify obesity. While obesity influences the onset of arthritis and type-2 diabetes, its effect on implant survival is still open to debate, with conflicting results from clinical and registry studies, as well as meta-analyses. Other known factors such as gender or diabetes status could ponderate or mask the effect of BMI on implant survival.
Hypothesis: Our hypothesis was BMI influenced hip and knee arthroplasty survival, when results were made independent of gender and diabetes status.
Patient and methods: A registry study was designed on 30733 Total Hip Arthroplasties (THA), 28483 Total Knee Arthroplasties (TKA), 3754 Uni compartmental Knee Arthroplasties (UKA) and 649 Hinged Knee arthroplasties (HK), from 01/01/2003 to 31/12/2015. Mean follow-up was 5.5 years. Diabetes status was added to the model. Each arthroplasty survival was tested for age at implantation, gender, diabetes status, implant characteristics and specifically BMI, taking into account gender and diabetes status.
Results: Gender had a strong influence on arthroplasty results. Age also influenced arthroplasty survival, especially aseptic loosening; a young age would lower implant survival. Diabetes had an influence in hip survival, but its influence on septic loosenings in TKA wasn't proven ($p = 0.065$). A mobile liner and/or a cruciate retaining knee were factors increasing the risk of revision. Weight influenced THA survival, especially aseptic loosening, but didn't have a measurable effect in any other arthroplasty. BMI was not found to influence any arthroplasty survival, whatever the endpoint, when diabetes and gender were taken into account.
Discussion: Gender, age and diabetes influenced survival of the lower limb arthroplasties, whereas BMI did not. Only weight did influence THA results and should be used instead of BMI.
Conclusion: Studies on arthroplasty survival should systematically mention gender and diabetes status and beware of potential group incomparability.
Level of evidence: III, cohort study.

1. Introduction

Obesity is a mechanical influencing factor for osteoarthritis [1] and a metabolic factor increasing prosthetic joint infections [2]. Its influence on hip or knee aseptic loosening also could be hinted, as obesity would increase the contact stresses on the implants, however conclusive evidence seems missing. A registry study by Bordini et al. [3]. found no influence of Body Mass Index (BMI) on TKA survival. Kerkhoffs [2] and Si et al. [4] cohort reviews did not find a correlation, while another registry study by Culliford et al. [5] did find a difference, but using 'revision for any cause' as the end point.

As gender was found to also have an influence on arthroplasty survival [6,7], Smith et al. [8] found that the apparent influence of BMI disappeared when taking into account gender. Obesity carries a higher risk for type-2 diabetes [9], and the effect of diabetes itself on arthroplasty survival, though controversial [10], could bias the potential effects of weight, or BMI, alone. In this regard, two registry studies by Wagner et al. on THA [11] and TKA [12] have concluded of an effect of BMI on implant revision, but the absence of evaluation of the diabetes status in the BMI cohorts, as well as gender repartition, could have prevented from distinguishing the distinct

☆ Investigation performed at IOR, Bologna, Italy.

* Corresponding author. Inserm, U1059, 42055 St-Étienne, France.
E-mail address: bertrand.boyer@chu-st-etienne.fr (B. Boyer).

https://doi.org/10.1016/j.otsr.2019.07.020
1877-0568/

Table 1
Repartition of gender and diabetes status according to BMI.

BMI	Males		Females	
	Diabetic	Non-diabetic	Diabetic	Non-diabetic
	n (%)	*n* (%)	*n* (%)	*n* (%)
Underweight (< 18)	2 (0.1)	74 (0.7)	19 (1.2)	528 (3.1)
Normal (18–25)	304 (21.2)	3276 (30.1)	445 (27.4)	6615 (39.4)
Overweight (25–30)	671 (46.8)	5265 (48.4)	636 (39.1)	6396 (38.1)
Obesity (30–40)	383 (26.7)	1788 (16.4)	414 (25.5)	2354 (14.0)
Morbid Obesity (> 40)	69 (0.6)	24 (1.7)	32 (2.0)	141 (0.8)
Missing	51 (3.6)	407 (3.7)	80 (4.9)	759 (4.5)
Total	1435	10879	1626	16793
Underweight (< 18)	–	11 (0.1)	7 (0.3)	113 (0.6)
Normal (18–25)	166 (12.7)	1398 (19.7)	308 (12.9)	3866 (21.9)
Overweight (25–30)	592 (45.2)	3708 (52.1)	848 (35.6)	7843 (44.4)
Obesity (30–40)	493 (37.6)	1840 (25.9)	1059 (44.5)	5235 (29.6)
Morbid Obesity (> 40)	36 (2.8)	57 (0.8)	117 (4.9)	362 (2.0)
Missing	23 (1.8)	102 (1.4)	42 (1.8)	257 (1.5)
Total	1310 (100.0)	7116 (100.0)	2381 (100.0)	17676 (100.0)
Underweight (< 18)	3 (0.3)	0 (-)	2 (0.9)	18 (0.8)
Normal (18–25)	223 (21.2)	15 (9.2)	31 (13.4)	583 (25.3)
Overweight (25–30)	594 (56.4)	85 (52.1)	98 (42.2)	1074 (46.6)
Obesity (30–40)	212 (20.1)	58 (35.6)	87 (37.5)	564 (24.5)
Morbid Obesity (> 40)	7 (0.7)	2 (1.2)	9 (3.9)	19 (0.8)
Missing	14 (1.3)	3 (1.8)	5 (2.2)	48 (2.1)
Total	163	1053	232	2306
Underweight (< 18)	–	1 (0.7)	–	15 (3.4)
Normal (18–25)	4 (16.7)	41 (30.1)	7 (14.9)	123 (27.8)
Overweight (25–30)	17 (70.8)	68 (50.0)	18 (38.3)	165 (37.3)
Obesity (30–40)	3 (12.5)	21 (15.4)	17 (36.2)	109 (24.7)
Morbid Obesity (> 40)	–	4 (2.9)	4 (8.5)	22 (5.0)
Missing	–	1 (0.7)	1 (2.1)	8 (1.8)
Total	24 (100)	136 (100)	47 (100)	442 (100.0)

effect of diabetes or gender in the results, thus affecting the authors' conclusions.

In knees, different kinds of arthroplasties could see different quantitative effects of BMI on revision [13]. Other studies focused on the influence of weight [14], not BMI. This different approach could prevent the ponderation effect of the height-squared denominator in the BMI formula.

BMI or weight also could have a nonlinear effect along the duration of implantation [2].

Our hypothesis was BMI influenced hip and knee arthroplasty survival, when results were made independent to gender and diabetes status.

2. Patients and methods

2.1. Patients

This study was designed as a registry study (Registro Implantologia Protesica Ortopedica, Bologna, Italy, https://ripo.cineca.it).

All analyses were based on primary operations in patients resident in the area of Emilia-Romagna. The analysis was limited to this cohort of patients. All bilateral cases were excluded, because of a dependency bias [15]. Were also excluded cases where patient's weight or diabetic condition was unknown and for THA, cemented or hybrid fixation and metal on metal (MoM) bearings with head size larger than 32 mm. Cemented stems were not found in sufficient numbers. MoM had issues that could bias the results [16].

In total, 12802 joints were excluded.

The estimation of the presence of diabetes follows Pedersen et al. [17].

2.2. Methods

In total, 30733 Total Hip Arthroplasties (THA), 28483 Total Knee Arthroplasties (TKA), 3754 Uni compartmental Knee Arthroplasties (UKA) and 649 Hinged Knee arthroplasties (HK) were included from 01/01/2003 to 31/12/2015. Mean follow-up was 5.5 years.

Each arthroplasty population was described through age groups, gender and diabetes status and BMI classification groups (Table 1), to look for group comparability.

2.3. Methods of assessment

A survivorship analysis, with revision for any cause, aseptic and septic loosenings as endpoints, was performed for each type of arthroplasty. For THA was also analysed the influence of the type of femoral neck; for TKA we also included the influence of the type of liner and the stabilization model.

A Cox proportional hazards model was built to look for the influence of different parameters on survival, age at surgery, gender, body weight and diabetes status.

Another Cox model was made, to look only for the influence of body weight on arthroplasty survival, without the influence of gender or diabetes status. For each gender and every arthroplasty, four groups were used: diabetic patients with a normal BMI, diabetic patients with overweight or obesity, non-diabetic patients of normal BMI versus overweight and obese.

2.4. Statistical analysis

The statistical analysis was performed using SPSS 14.0 for Windows, version 14.0.1 (SPSS Inc, Chicago, IL, USA.

BMI was set as a continuous variable in order to allow using parametric tests and maximizing the power of the analysis, but ordinal BMI was also used for comparison.

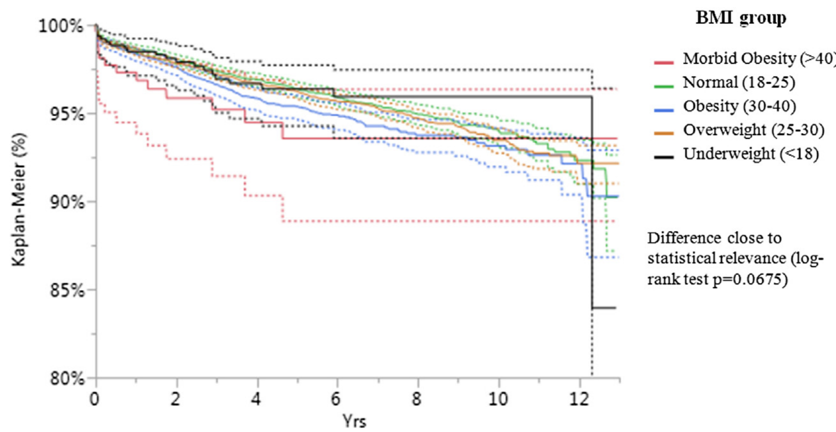

Fig. 1. Survival analysis according to Kaplan-Meier of the different groups for THA, ranked by Bone Mass Index allowed testing survival differences. Endpoint: revision for any cause (log-rank test, $p = 0.0675$).

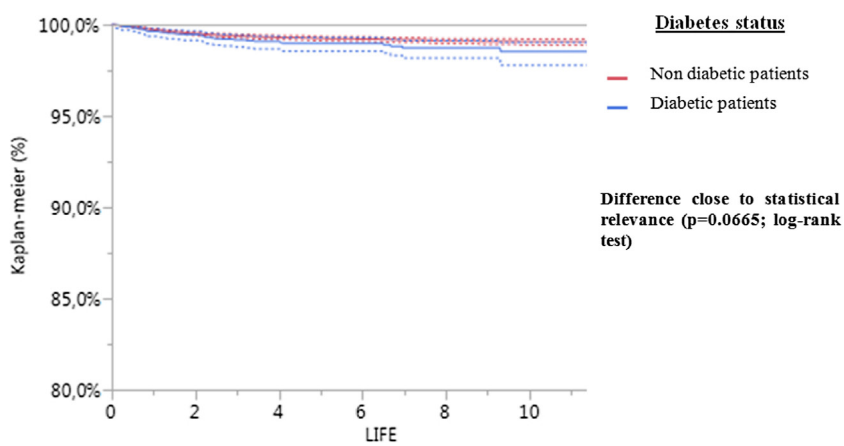

Fig. 2. We compared Kaplan Meier's survival curves of diabetic and non-diabetic TKAs, with septic loosening set as end point (log-rank test, $p = 0.0665$).

The survival curves and log-rank tests were calculated and plotted according to Kaplan-Meier. Hazard ratios were calculated via a Cox multivariate regression model.

3. Results

3.1. Survival analysis

3.1.1. Endpoint: revision for any cause

With Diabetes status, no difference between the two populations was found ($p = 0.1635$ for THA; $p = 0.58$ for TKA, $p = 0.7487$ for UKA and $p = 0.4665$ for HK).

When the population was divided in 5 BMI groups, only in THA we found a difference close to significance ($p = 0.0675$, Fig. 1). It was not the case for TKA ($p = 0.65$), UKA ($p = 0.4697$) or HK ($p = 0.7683$).

With gender, a difference was found in favor of females in hips and hinged knees ($p = 0.0003$ for THA, $p = 0.0424$ for HK). For TKA ($p = 0.1062$) and UKA ($p = 0.2034$) no survival difference was proven.

Fixed liners would have a better survival than mobile liners ($p < 0.0001$). A significant difference was also found in favour of PS knees when comparing CR and PS knees, but only in the log-rank test ($p = 0.0346$).

3.1.2. Endpoint: revision for septic loosening

When we looked at the diabetes status, in total hips was found a difference ($p = 0.0221$); diabetic patients had a worst survival with regard of septic loosening. It couldn't be proven for total knees ($p = 0.0665$, respectively; Fig. 2). In unicompartimental ($p = 0.4376$) or hinged ($p = 0.4277$) knees no difference was highlighted.

When the population was ranked in 5 BMI groups, no difference could be found in either arthroplasty (THA $p = 0.6717$, TKA $p = 0.4873$, UKA $p = 0.9590$, HK $p = 0.7627$). Fig. 3 shows the results for TKA.

With gender, a significant difference in favour of females was highlighted in hips ($p = 0.0108$), total knees ($p = 0.0001$) and hinged knees ($p = 0.0034$) but not in UKA ($p = 0.7487$).

For arthroplasty-specific issues, i.e., THA neck modularity ($p = 0.9739$), TKA liner mobility ($p = 0.2929$) or stabilization ($p = 0.3748$), we did not find differences when septic loosening was set as endpoint.

3.1.3. Endpoint: revision for aseptic loosening

Diabetes status did not influence survival for aseptic loosening ($p = 0.1785$ for THA, $p = 0.9657$ for TKA, $p = 0.1186$ for UKA, $p = 0.5433$ for HK). BMI also did not influence survival for aseptic loosening ($p = 0.8095$ for THA, $p = 0.4517$ for TKA, $p = 0.4561$ for UKA, $p = 0.9064$ for HK). Gender was not a factor of influence for THA ($p = 0.2034$), TKA ($p = 0.8752$) or HK ($p = 0.4645$), but we found a significant difference in favor of females in UKA ($p = 0.0175$).

In total knees, fixed liners (versus mobile, $p < 0.001$) and posterior stabilized (vs cruciate retaining, $p = 0.0324$) total knees had a better survival concerning aseptic loosening.

3.1.4. Cox model

A Cox model testing age, gender, weight and diabetes as factors and with endpoints revision for any cause, revision for septic loosening or revision for aseptic loosening was built for THA (Table 2), TKA (Table 3), UKA (Table 4) and HK (Table 5).

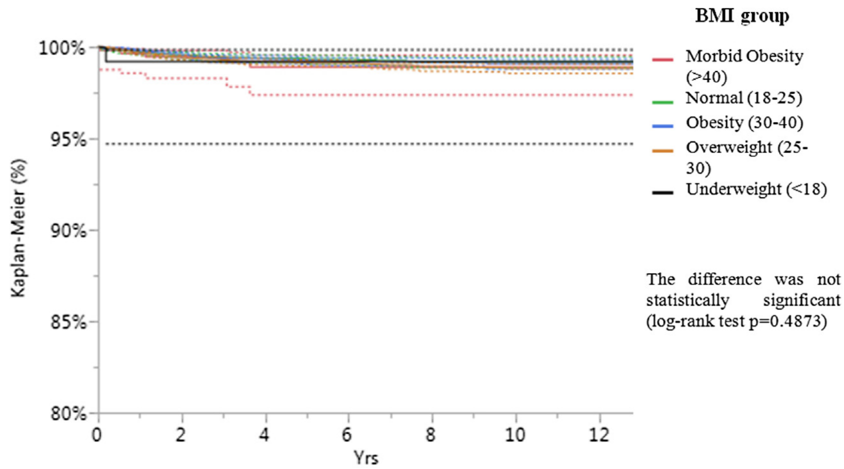

Fig. 3. Comparison of Kaplan Meier's survival curves of TKAs of each BMI group, with septic loosening set as end point (log-rank test, $p = 0.4873$) did not allow highlighting a difference.

Table 2
Influence on THA survival.

Parameter	Revision for any cause	Revision for septic loosening	Revision for aseptic loosening
	p	*p*	*p*
Age	< 0.0001*	0.0035*	< 0.0001*
Gender	< 0.0001*	0.2246	< 0.0001*
Diabetes status	< 0.0001*	0.0307*	< 0.0001*
Weight	0.0006*	0.1251	< 0.0001*

*:statistical significance.

Table 3
Influence on TKA survival.

Parameter	Revision for any cause	Revision for septic loosening	Revision for aseptic loosening
	p	*p*	*p*
Age	< 0.0001*	< 0.0001*	< 0.0001*
Gender	0.4298	< 0.0001*	0.6662
Diabetes status	0.5950	0.0682	0.8153
Weight	0.4959	0.5754	0.2822

*:statistical significance.

Table 4
Influence on UKA survival.

Parameter	Revision for any cause	Revision for septic loosening	Revision for aseptic loosening
	p	*p*	*p*
Age	0.1789	0.0006*	0.0195*
Gender	< 0.0001*	< 0.0001*	< 0.0001*
Diabetes status	0.2137	0.1530	0.3444
Weight	0.9620	0.8331	0.8781

*:statistical significance.

Table 5
Influence on HK survival.

Parameter	Revision for any cause	Revision for septic loosening
	p	*p*
Age	0.3253	0.0099*
Gender	0.0593	0.0296*
Diabetes status	0.1809	0.2999
Weight	0.1649	0.2390

*:statistical significance.

A hazard ratio with statistical significance was obtained for almost every arthroplasty with regard to the influence of gender (male/female), between 1.11 in THA [1.08; 1.14] and 1.3 in UKA [1.2;1.4] Hinged knee survival was only influenced by gender in septic loosening (4 [1.16; 14.9]).

Diabetes hazard ratio in hip septic loosening was evaluated at 2.02 [1.02; 3.68]; as the difference in total knees was only close to the statistical threshold ($p = 0.068$), we couldn't measure the effect of diabetes in total knee septic loosening, showing the same tendency as the survival analysis (log rank $p = 0.065$).

A sub-analysis was performed with the same data, but separating males and females; there was an influence of diabetes on septic loosening in females (in hip and knees, respectively $p = 0.0262$ and $p = 0.0409$) but not in males ($p = 0.8123$ in hips, $p = 0.6321$ in total knees).

In TKA, mobile liners had a hazard ratio of 1.286 [1.127; 1.466]; a male gender had a hazard ratio of 1.91 [1.42; 2.56] in septic loosening.

In UKA, gender had an influence on the three events, from 1.25 [1.16; 1.35] in septic loosening to 1.29 [1.19; 1.39] in aseptic loosening. Diabetes did not influence septic loosening ($p = 0.153$), even when selecting only females ($p = 0.999$).

In hinged knees, only septic loosenings were influenced by the factors we investigated. Aside from the influence of gender already mentioned, age had a hazard ratio of 0.94 [0.9; 0.99].

Weight was only found influencing aseptic loosening in hips, with a risk of 1.0016/kg [1.001; 1.003], with a risk of age on the same event of 1.01/year [1.009; 1.011].

3.1.4.1. Influence of BMI when groups were made comparable. For each arthroplasty the population was divided in four groups: diabetic males (DM), non-diabetic males (NM), diabetic females (DF), non-diabetic females (NF).

In THA, no statistically significant difference between the groups was found with regard to the incidence of BMI on revision for any cause (DM $p = 0.6617$; NM $p = 0.2165$; DF $p = 0.5374$; NF $p = 0.5714$), revision for septic loosening (DM $p = 0.9994$; NM $p = 0.5889$; DF $p = 0.9994$; NF $p = 0.7617$) or even revision for aseptic loosening (DM $p = 0.4215$; NM $p = 0.8533$; DF $p = 0.9162$; NF $p = 0.8194$).

In TKA, no difference was found with regard to the incidence of BMI on revision for any cause (DM $p = 0.1015$; NM $p = 0.7290$; DF $p = 0.6390$; NF $p = 0.3353$), septic loosening (DM $p = 0.0636$; NM $p = 0.9443$; DF $p = 0.9030$; NF $p = 0.2176$) or aseptic loosening (DM $p = 0.8740$; NM $p = 0.6113$; DF $p = 0.8207$; NF $p = 0.4642$).

In UKA, no statistically significant difference could be highlighted between the groups with regard to the incidence of BMI on revision for any cause (DM $p = 0.8322$; NM $p = 0.5035$; DF $p = 0.0882$; NF $p = 0.0689$), revision for septic loosening (DM $p = 0.9994$; NM $p = 0.1111$; DF = 0.4269; NF $p = 0.4572$) or even revision for aseptic loosening (DM $p = 0.6691$; NM $p = 0.1514$; DF $p = 0.1023$; NF $p = 0.4304$).

4. Discussion

While obesity is usually admitted as a factor influencing the onset of arthritis [1] and type 2 diabetes [9], its direct influence on implant survival is still open to debate.

No incidence of BMI on revision could be extracted from the model, when the influencing factors (gender and diabetes status) were equally distributed [18–23]. We could reject our hypothesis.

Gender had a strong influence on arthroplasty results. It also had a strong influence on septic loosenings. This result concurred with findings from Culliford et al. [5] and the registry study from Bordini et al. [6,7]. The causes for this gender difference are open for debate.

While influencing survival in THA, diabetes only had an influence on septic loosening close to reaching statistical significance in total knees. Diabetic males did not have an increased risk compared with non-diabetics on implant septic loosening, which was a new finding to our knowledge; while diabetic females indeed have an increased risk of septic loosening. The cause of this gender difference is also not clear and should be investigated. As our registry does not include patients re operated but not having their implants revised, these seemingly disturbing results [24–29] could be explained by a probably more marked influence of diabetes on healing issues and soft-tissue infection [30] rather than on septic loosening itself, as Yang et al. [31]. The control of the disease also might impact the results [32].

Weight did influence THA survival but no other arthroplasty for any cause of revision.

In knees, soft tissue could allow dissipating at least part of the constraints on the liner [33].

In TKA, a mobile liner and/or a cruciate retaining knee were factors increasing the risk of revision, a result also found in other registry studies [34,35].

Studies on hips and knees from Wagner et al. [11,12] had opposite results compared with our findings on the effect of BMI. An explanation could be hinted when looking back at Table 1. There was a different pattern of diabetes status repartition following BMI in the two genders. Females also represented 65% of morbidly obese hips while only 56% of obese hips.

As we proved gender and diabetes status influenced survival, a different repartition of one of these parameters between groups could have biased the results, the patient groups being incomparable. Smith et al. [8] similarly found no influence of weight when taking into account gender.

Data from diabetes status or gender repartition between the BMI groups was not available from these studies.

4.1. Study limits

Our study shared the same limits as every registry study, such as the absence of clinical findings and satisfaction scores. With septic revisions, if implants were not removed, data was not available in the registry, so infections treated with only debridement and lavage were not included.

The rule in the case of a Debridement, Antibiotics and Implant Retention is however to change the modular pieces, considered as failures by our study.

While our study has a unique focus on diabetes and implant survival, we did not have indications on the disease itself.

5. Conclusions

Gender, age and diabetes status influenced survival of the lower limb arthroplasties. BMI did not have an influence on implant survival. Only weight did influence THA results and should be used instead of BMI. A follow-up study on hips could allow better comprehend other potential influencing factors such as head diameter or bearing couple.

Studies on arthroplasty survival should systematically mention gender and diabetes status and their repartition in each group and beware of potential group incomparability. Glycemic marker levels would be interesting in registry studies involving diabetic patients.

Disclosure of interest

Bertrand Boyer and Thomas Neri are consultants for SERF (Décines, France). Aldo Toni receives royalties from Adler (Milan, Italy). The other authors delare that they have no competing interest.

Funding

We would like to thank the SOciété Française de Chirurgie Orthopédique et Traumatologie (SOFCOT) for its grant, allowing this study to happen.

Authors' contribution

Susanna Stea and Aldo Toni were responsible for data collect, loss of follow-up reduction strategies and manuscript overseeing; Barbara Bordini and Dalila Caputo were responsible for the statistical analysis and survival modeling; Thomas Neri was responsible for manuscript building and redaction, especially material and methods and results; Bertrand Boyer organized the study, built the manuscript and was responsible for introduction and discussion parts of the manuscript.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2019.07.020.

References

[1] Stürmer T, Günther K-P, Brenner H. Obesity, overweight and patterns of osteoarthritis: the Ulm Osteoarthritis Study. J Clin Epidemiol 2000;53:307–13.
[2] Kerkhoffs GMMJ, Servien E, Dunn W, Dahm D, Bramer JA, Haverkamp D. The influence of obesity on the complication rate and outcome of total knee arthroplasty: a meta-analysis and systematic literature review. J Bone Jt Surg-Am Vol 2012;94:1839–44.
[3] Bordini B, Stea S, Cremonini S, Viceconti M, De Palma R, Toni A. Relationship between obesity and early failure of total knee prostheses. BMC Musculoskelet Disord 2009;10:29.
[4] Si H, Zeng Y, Shen B, Yang J, Zhou Z, Kang P, et al. The influence of body mass index on the outcomes of primary total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2015;23:1824–32.
[5] Culliford D, Maskell J, Judge A, Arden NK, COAST study group. A population-based survival analysis describing the association of body mass index on time to revision for total hip and knee replacements: results from the UK general practice research database. BMJ Open 2013;3:e003614.
[6] Bordini B, Stea S, Toni A. A different point of view on sex and risk of hip implant failure and failure rate in women. JAMA Intern Med 2013;173:1557–8.
[7] Bordini B, Stea S, De Clerico M, Strazzari S, Sasdelli A, Toni A. Factors affecting aseptic loosening of 4750 total hip arthroplasties: multivariate survival analysis. BMC Musculoskelet Disord 2007;8:69.
[8] Smith BE, Askew MJ, Gradisar IA, Gradisar JS, Lew MM. The effect of patient weight on the functional outcome of total knee arthroplasty. Clin Orthop 1992;276:237–44.
[9] Kodama S, Horikawa C, Fujihara K, Yoshizawa S, Yachi Y, Tanaka S, et al. Quantitative relationship between body weight gain in adulthood and incident type 2 diabetes: a meta-analysis. Obes Rev 2014;15:202–14.
[10] Adams AL, Paxton EW, Wang JQ, Johnson ES, Bayliss EA, Ferrara A, et al. Surgical outcomes of total knee replacement according to diabetes status and glycemic control, 2001 to 2009. J Bone Joint Surg Am 2013;95:481–7.
[11] Wagner ER, Kamath AF, Fruth KM, Harmsen WS, Berry DJ. Effect of body mass index on complications and reoperations after total hip arthroplasty. J Bone Joint Surg Am 2016;98:169–79.
[12] Wagner ER, Kamath AF, Fruth K, Harmsen WS, Berry DJ. Effect of body mass index on reoperation and complications after total knee arthroplasty. J Bone Joint Surg Am 2016;98:2052–60.
[13] Ranawat CS, Boachie-Adjei O. Survivorship analysis and results of total condylar knee arthroplasty. Eight- to 11-year follow-up period. Clin Orthop 1988;226:6–13.
[14] Hood RW, Wright TM, Burstein AH. Retrieval analysis of total knee prostheses: a method and its application to 48 total condylar prostheses. J Biomed Mater Res 1983;17:829–42.
[15] Park MS, Kim SJ, Chung CY, Choi IH, Lee SH, Lee KM. Statistical consideration for bilateral cases in orthopaedic research. J Bone Joint Surg Am 2010;92:1732–7.
[16] Clarke-Jenssen J, Westberg M, Røise O, Storeggen SAØ, Bere T, Silberg I, et al. Reduced survival for uncemented compared to cemented total hip arthroplasty after operatively treated acetabular fractures. Injury 2017;48:2534–9.
[17] Pedersen AB, Mehnert F, Johnsen SP, Sørensen HT. Risk of revision of a total hip replacement in patients with diabetes mellitus: a population-based follow up study. J Bone Joint Surg Br 2010;92:929–34.
[18] Foran JRH, Mont MA, Rajadhyaksha AD, Jones LC, Etienne G, Hungerford DS. Total knee arthroplasty in obese patients: a comparison with a matched control group. J Arthroplasty 2004;19:817–24.
[19] Griffin FM, Scuderi GR, Insall JN, Colizza W. Total knee arthroplasty in patients who were obese with 10 years follow-up. Clin Orthop 1998;356:28–33.
[20] Hamoui N, Kantor S, Vince K, Crookes PF. Long-term outcome of total knee replacement: does obesity matter? Obes Surg 2006;16:35–8.
[21] Houdek MT, Wagner ER, Watts CD, Osmon DR, Hanssen AD, Lewallen DG, et al. Morbid obesity: a significant risk factor for failure of two-stage revision total hip arthroplasty for infection. J Bone Joint Surg Am 2015;97:326–32.
[22] Husted H, Jørgensen CC, Gromov K, Kehlet H. Lundbeck Foundation Center for Fast-track Hip and Knee Replacement Collaborative Group. Does BMI influence hospital stay and morbidity after fast-track hip and knee arthroplasty? Acta Orthop 2016;87:466–72.
[23] Garcia-Cimbrelo E, Cruz-Pardos A, Cordero J, Sanchez-Sotelo J. Low-friction arthroplasty in patients younger than 40 years old: 20- to 25-year results. J Arthroplasty 2000;15:825–32.
[24] Halley DK, Glassman AH. Twenty- to twenty-six-year radiographic review in patients 50 years of age or younger with cemented Charnley low-friction arthroplasty. J Arthroplasty 2003;18:79–85.
[25] England SP, Stern SH, Insall JN, Windsor RE. Total knee arthroplasty in diabetes mellitus. Clin Orthop 1990:130–4.
[26] Han H-S, Kang S-B. Relations between long-term glycemic control and postoperative wound and infectious complications after total knee arthroplasty in type 2 diabetics. Clin Orthop Surg 2013;5:118–23.
[27] Jämsen E, Nevalainen P, Eskelinen A, Huotari K, Kalliovalkama J, Moilanen T. Obesity, diabetes, and preoperative hyperglycemia as predictors of periprosthetic joint infection: a single-center analysis of 7181 primary hip and knee replacements for osteoarthritis. J Bone Joint Surg Am 2012;94:e101.
[28] Jämsen E, Nevalainen P, Kalliovalkama J, Moilanen T. Preoperative hyperglycemia predicts infected total knee replacement. Eur J Intern Med 2010;21:196–201.
[29] Namba RS, Inacio MCS, Paxton EW. Risk factors associated with deep surgical site infections after primary total knee arthroplasty: an analysis of 56,216 knees. J Bone Joint Surg Am 2013;95:775–82.
[30] Pruzansky JS, Bronson MJ, Grelsamer RP, Strauss E, Moucha CS. Prevalence of modifiable surgical site infection risk factors in hip and knee joint arthroplasty patients at an urban academic hospital. J Arthroplasty 2014;29:272–6.
[31] Yang Z, Liu H, Xie X, Tan Z, Qin T, Kang P. The influence of diabetes mellitus on the post-operative outcome of elective primary total knee replacement: a systematic review and meta-analysis. Bone Jt J 2014;96–B:1637–43.
[32] Hwang JS, Kim SJ, Bamne AB, Na YG, Kim TK. Do glycemic markers predict occurrence of complications after total knee arthroplasty in patients with diabetes? Clin Orthop 2015;473:1726–31.
[33] Battaglia S, Taddei P, Tozzi S, Sudanese A, Affatato S. Toward the interpretation of the combined effect of size and body weight on the tribological performance of total knee prostheses. Int Orthop 2014;38:1183–90.
[34] Graves S, Sedrakyan A, Baste V, Gioe TJ, Namba R, Martínez Cruz O, et al. International comparative evaluation of knee replacement with fixed or mobile-bearing posterior-stabilized prostheses. J Bone Joint Surg Am 2014;96:59–64.
[35] Namba RS, Inacio MCS, Paxton EW, Ake CF, Wang C, Gross TP, et al. Risk of revision for fixed versus mobile-bearing primary total knee replacements. J Bone Joint Surg Am 2012;94:1929–35.