Overweight and obesity in hip and knee arthroplasty: Evaluation of 6078 cases

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Abstract

AIM: To evaluate a possible association between the various levels of obesity and peri-operative characteristics of the procedure in patients who underwent endoprosthetic joint replacement in hip and knee joints.

METHODS: We hypothesized that obese patients were treated for later stage of osteoarthritis, that more conservative implants were used, and the intra- and perioperative complications increased for such patients. We evaluated all patients with body mass index (BMI) ≥ 25 who were treated in our institution from January 2011 to September 2013 for a primary total hip arthroplasty (THA) or total knee arthroplasty (TKA). Patients were split up by the levels of obesity according to the classification of the World Health Organization. Average age at the time of primary arthroplasty, preoperative Harris Hip Score (HHS), Hospital for Special Surgery score (HSS), gender, type of implanted prosthesis, and intra- and postoperative complications were evaluated.

RESULTS: Six thousand and seventy-eight patients with a BMI ≥ 25 were treated with a primary THA or TKA. Age decreased significantly (P < 0.001) by increasing obesity in both the THA and TKA. HHS and HSS were at significantly lower levels at the time of treatment in the super-obese population (P < 0.001). Distribution patterns of the type of endoprostheses used changed with an increasing BMI. Peri- and postoperative complications were similar in form and quantity to those of the normal population.

CONCLUSION: Higher BMI leads to endoprosthetic treatment in younger age, which is carried out at significantly lower levels of preoperative joint function.

Key words: Adiposity; Total knee arthroplasty; Total hip arthroplasty; Obesity; Overweight; Prosthesis

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Core tip: Our study demonstrates that total hip arthroplasty and total knee arthroplasty can be performed in all stages of obesity with low perioperative risk. We have to mention that good preparation is indispensable. Co-morbidities should be assessed and the set-up should be related to high weight. Sometimes special operation-tables, beds, and crutches are required. Higher body mass index leads to endoprosthetic treatment in younger age, which is carried out at significantly lower levels of preoperative joint function.

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INTRODUCTION

The prevalence of overweight patients is steadily increasing in the general population. 67.1 % of men and 53.0% of women in our country have a body mass index (BMI) ≥ 25 kg/m². 23.3% of men and 23.9% of women have a BMI ≥ 30 kg/m².[9] The data of the world's population are similar to this[9]. As defined by BMI, 1 of every 3 Americans is overweight[3]. It is known that obesity has a negative influence on the formation of osteoarthritis[5]. An increased BMI leads to an increased risk of needing a joint replacement. Waist circumference and waist-to-hip ratio were less strongly associated with this risk[3]. Several studies have examined the influence of obesity on the need for endoprosthetic joint replacement[3,5]. However, to our knowledge, there is no study that evaluated the influence of the respective stage of obesity in a monocentric setting with large number of cases. If a decision for an endoprosthetic joint replacement was made, the kind of implant for artificial hip and knee arthroplasty is up to the individual surgeon.

Obese patients with severe osteoarthritis, axis deviation, and ligamentous instability are a major challenge for the surgeon[8]. These patients often lack the ability of postoperative partial weight bearing. There is no study in modern literature that deals with the influence of obesity on the choice of the individual implant.

There are studies showing that obesity is associated with an increased risk of infection and impaired wound healing[4]. However, a large number of morbidly obese people seem to consider that the benefits outweigh the risks[6,8].

The aim of this study was to evaluate if there is an association between the various levels of obesity and peri-operative characteristics of the procedure in patients who underwent total hip arthroplasty (THA) and total knee arthroplasty (TKA). Furthermore, it should be issued if an increasing BMI has an influence on the choice of the implant by the individual surgeon and whether the intra- and perioperative complications are increased or not. We hypothesized that obese patients were treated with later stage of OA and more advanced stage implants like cemented THA and constrained TKA.

MATERIALS AND METHODS

We evaluated all patients with a BMI ≥ 25 kg/m², who were treated in the period from January 2011 to September 2013 in our institution for a primary THA or TKA. These patients were split up by stages of obesity according to the classification of the World Health Organization[1]. Data from the hospitals database were analyzed.

We evaluated the average age at time of primary arthroplasty. Furthermore data collection included the preoperative Harris Hip Score (HHS) for total hip arthroplasty[2], the Hospital for Special Surgery Score (HSS) for total knee arthroplasty[2], the gender, the type of implanted prosthesis, the comorbidities and the intra-and postoperative complications. The study was conducted according to the guidelines of the local ethics committee. Informed consent for this retrospective study was obtained from every single patient.

The data were processed with the statistical software package SPSS (version 20.0, SPSS Inc., Chicago, United States). Interference statistical analyses were performed for two independent samples using the Mann-Whitney U test. The Kruskall-Wallis test was used to check several independent samples. Multivariate analysis was performed to evaluate whether there is an independent association between the level of obesity, BMI, functional status (HHS/HSS), gender and age at THA/TKA. Logistic regression was performed to evaluate the association between BMI, gender, functional status and the used prosthesis type.

A power analysis was performed based on previously reported values of HHS and HSS following THA and TKA. It was determined that the available sample size was sufficient to detect a ten point difference in the scores between the groups with α = 0.05 and a power of 0.95.

RESULTS

In the period from January 2011 to September 2013, 9742 primary hip or knee arthroplasties were performed in our institution. Six thousand and seventy-eight patients with a BMI ≥ 25 kg/m² were treated with a primary hip or knee arthroplasty (62.4 % of total number of primary THA and TKA).

Table 1 presents the distribution of patients to the different stages of overweight and obesity. The dissemination of comorbidities was comparable between the different stages (Table 2). The age in which an endoprosthetic treatment was necessary decreased significantly (P < 0.001) by increasing overweight and obesity in both the hip and knee arthroplasty. In the higher stages of obesity, both HHS and HSS were at significantly lower levels at the
time of prosthetic treatment compared to overweight or obese stage I patients \((P < 0.001)\) (Tables 3 and 4).

A correlation between anthropometric data (gender, BMI, stages of overweight/obesity) and functional scores (HHS/HSS) could be shown with the strongest negative correlation between BMI and functional scores in TKA as well as in THA. A correlation between anthropometric data and age of arthroplasty could be shown with the strongest negative correlation between BMI and age of arthroplasty in THA and HHS and age of arthroplasty in TKA (Tables 5 and 6).

In all stages of obesity, the surgeons used a similar distribution pattern of the different types of hip prostheses. In the super-obese population, more cementless alternatives were used instead of fully cemented or hybrid prostheses (Tables 7 and 8).

In the knee replacement surgery, the surgeons used a similar distribution pattern of implants in the overweight and obese stage I patients. With increasing BMI more bicondylar surface replacements and less hinge prostheses or constrained condylar knees (long stem) were used. The use of unicompartmental knee replacement declined with increasing BMI (Tables 9 and 10).

The peri- and postoperative complications were similar in form and quantity to those of the normal population (Tables 11 and 12).

**DISCUSSION**

Our study shows that the time of primary implantation of a total hip or total knee arthroplasty is significantly influenced by the stage of obesity. In our study, patients who have had a higher BMI needed endoprosthesis joint replacement at a younger age. It is noticeable that the primary implantation was carried out at significantly lower function scores (HHS, HSS) with increasing BMI. This suggests that super-obese patients were treated much more cautiously than overweight or normal weight patients. In higher stages of obesity, more cementless total hip arthroplasties were carried out than fully cemented or hybrid alternatives. An explanation for that could be the shorter time of surgery for cementless arthroplasty. This can sometimes become necessary in this high-risk population such as multimorbid patients. Obesity is associated with multiple comorbidities such as type II diabetes and cardiovascular disease\[13\].

It is known that obese patients have a high risk of formation of osteoarthritis. Due to the high weight-
### Table 3 Pre-total hip arthroplasty comparison of the different study groups

| BMI (kg/m²) | 25-29.9 (Overweight) | 30-34.9 (Stage I) | 35-39.9 (Stage II) | ≥ 40 (Stage III) | P value |
|-------------|----------------------|-------------------|--------------------|-----------------|---------|
| Gender (percent male) | 961/959 (50.0%) | 445/454 (49.5%) | 121/164 (42.5%) | 34/36 (46.6%) | < 0.001 |
| Age at the time of Arthroplasty (years) | 65.8 ± 11.0 | 63.7 ± 11.0 | 62.6 ± 10.6 | 58.9 ± 10.2 | < 0.001 |
| Harris Hip Score | 47.1 ± 12.5 | 44.8 ± 12.4 | 42.2 ± 13.1 | 37.7 ± 12.1 | < 0.001 |
| Weight (kilograms) | 80.7 ± 9.8 | 94.4 ± 11.5 | 107.8 ± 12.8 | 125.9 ± 18.2 | < 0.001 |

BMI: Body mass index.

### Table 4 Pre-total knee arthroplasty comparison of the different study groups

| BMI (kg/m²) | 25-29.9 (overweight) | 30-34.9 (Stage I) | 35-39.9 (Stage II) | ≥ 40 (Stage III) | P value |
|-------------|----------------------|-------------------|--------------------|-----------------|---------|
| Gender (percent male) | 596/798 (42.7%) | 368/593 (38.3%) | 116/316 (26.8%) | 33/84 (28.2%) | < 0.001 |
| Age at the time of Arthroplasty (yr) | 68.2 ± 9.7 | 65.9 ± 9.3 | 64.2 ± 9.2 | 62.8 ± 7.0 | < 0.001 |
| Hospital for Special Surgery Score | 55.7 ± 13.1 | 54.2 ± 13.3 | 50.6 ± 13.1 | 49.3 ± 13.8 | < 0.001 |
| Weight (kg) | 79.9 ± 9.9 | 92.9 ± 11.5 | 103.7 ± 13.3 | 119.6 ± 16.5 | < 0.001 |

BMI: Body mass index.

### Table 5 Relationships between age at total hip arthroplasty, Harris Hip Score, body mass index, stages of overweight/obesity and gender

| | Age at THA | Regression coefficient | P value | HHS | Regression Coefficient | P value |
|-------------|------------------|------------------------|---------|------------------------|---------|
| BMI         | -0.178 (-0.226 to -0.13) | < 0.001 | -0.201 (-0.256 to -0.146) | < 0.001 |
| HHS         | -0.217 (-0.232 to -0.202) | < 0.001 | -0.152 (-0.208 to 0.146) | < 0.001 |
| Gender      | 0.112 (-0.268 to 0.492) | < 0.001 | -0.099 (-0.537 to 0.339) | < 0.001 |
| Overweight  | 0.139 (-0.251 to 0.529) | < 0.001 | 0.148 (-0.301 to 0.597) | < 0.001 |
| Stage I     | -0.098 (-0.529 to 0.333) | < 0.001 | -0.099 (-0.594 to 0.396) | < 0.001 |
| Stage II    | -0.110 (-0.786 to 0.566) | < 0.001 | -0.125 (-0.901 to 0.651) | < 0.001 |
| Stage III   | -0.116 (-1.427 to 1.195) | < 0.001 | -0.127 (-1.631 to 1.377) | < 0.001 |
| Age at THA  | -0.215 (-0.415 to -0.195) | < 0.001 | -0.157 (-0.360 to 0.047) | < 0.001 |

BMI: Body mass index; THA: Total hip arthroplasty; HHS: Harris Hip Score.

### Table 6 Relationships between age at total knee arthroplasty, Harris Hip Score, body mass index, stages of overweight/obesity and gender

| | Age at TKA | Regression coefficient | P value | HSS | Regression Coefficient | P value |
|-------------|------------------|------------------------|---------|------------------------|---------|
| BMI         | -0.224 (-0.263 to 0.185) | < 0.001 | -0.152 (-0.208 to 0.096) | < 0.001 |
| HSS         | -0.118 (-0.132 to -0.104) | < 0.001 | -0.128 (-0.641 to 0.385) | < 0.001 |
| Gender      | 0.076 (-0.294 to 0.446) | < 0.001 | 0.115 (-0.39 to 0.62) | < 0.001 |
| Overweight  | 0.184 (-0.175 to 0.543) | < 0.001 | -0.063 (-0.623 to 0.479) | < 0.001 |
| Stage I     | -0.129 (-0.529 to 0.271) | < 0.001 | -0.138 (-0.885 to 0.609) | < 0.001 |
| Stage II    | -0.181 (-0.715 to 0.353) | < 0.001 | -0.100 (-1.386 to 1.186) | < 0.001 |
| Stage III   | -0.130 (-1.051 to -0.791) | < 0.001 | -0.118 (-0.144 to -0.092) | < 0.001 |

BMI: Body mass index; TKA: Total knee arthroplasty; HSS: Harris Hip Score.

### Table 7 Distribution pattern of implanted total hip arthroplasty

| BMI (kg/m²) | 25-29.9 (Overweight total) | 30-34.9 (Stage I) | 35-39.9 (Stage II) | ≥ 40 | (Stage III) |
|-------------|-----------------------------|-------------------|--------------------|------|-------------|
| Cementless short stem | 535 | 27.9 | 253 | 28.10 | 76 | 26.7 | 20 | 28.6 |
| Cementless standard stem | 585 | 30.5 | 297 | 33.00 | 109 | 38.2 | 27 | 38.6 |
| Hybrid (cemented/cementless) | 43 | 2.2 | 22 | 2.40 | 8 | 2.8 | 3 | 4.3 |
| Cemented THA | 757 | 39.4 | 327 | 36.40 | 92 | 32.3 | 20 | 28.6 |
| Total amount | 1920 | 899 | 285 | 70 | |

THA: Total hip arthroplasty; BMI: Body mass index.
related load on the skeleton, obese patients often have good bone quality. Yet in obese patients who have a lack of physical activity and sometimes hormonal disbalances, a poorer bone quality is frequently found. However, these patients often do not manifest complaints due to their low level of activity.14.

In the knee replacement surgery in stage III obese patients, surgeons used almost no hinge prostheses or constrained condylar knees. Super-obese patients with a distribution pattern of pitfalls such as severe axis deviations and ligamentous instabilities are often preoperatively convinced to lose weight. Studies have shown that weight loss is effective for symptomatic relief in obese subjects with knee osteoarthritis independently of joint damage severity.15. In this patient group, the risk of complications following joint replacement appears to be lower if bariatric surgery is performed first.14.

Isolated medial gonarthrosis seems to be much less common in this group of patients. Due to this fact, unicompartmental knee replacements or osteotomies have not been performed at all in the super-obese population at our institution in this time period. Some studies mention that there is a significant increased risk for complications in the super-obese population.17-19. Some authors determined that there is no increased risk in this population.19,20. In our institution the peri-and postoperative complication rate was not increased significantly by increasing BMI. Sometimes total hip arthroplasties in obese patients were perceived by the surgeon to be significantly more difficult. However, in this cases neither increased risk of complications, operation time, or blood loss, nor suboptimal implant placements have been observed.21.

We have to mention that good preparation is indispensable. Co-morbidities should be assessed and the set-up should be related to high weight. Sometimes special operation-tables, beds, and crutches are required. The long-time outcome after the duration of years will be interesting. Obese patients showed greater improvement according to functional outcome compared with non-morbidly obese patients. Morbid obesity does not affect 1-year outcomes in patients who have had a total knee arthroplasty.22. TKA benefits were realized at all stages

Table 8 Relationships between preferred prosthesis type, age at total hip arthroplasty, Harris Hip Score, body mass index, stages of overweight/obesity and gender

| BMI (kg/m²) | 25-29.9 total | 30-34.9 total | 35-39.9 total | ≥ 40 total | (Stage I) percent | (Stage II) percent |
|-------------|---------------|---------------|---------------|------------|------------------|------------------|
| Bicondylar surface replacement | 1246 | 89.40% | 878 | 91.40% | 403 | 93.30 | 116 | 99.10% |
| Long stem | 60 | 4.30% | 43 | 4.50% | 22 | 5.00 | 1 | 0.90% |
| PFJ | 10 | 0.70% | 5 | 0.50% | 3 | 0.70 | 0 | 0.00% |
| Unicompartmental knee replacement | 78 | 5.60% | 35 | 3.60% | 4 | 0.90 | 0 | 0.00% |
| Total amount | 1394 | 961 | 432 | 117 |                  |                  |

BMI: Body mass index.
of BMI, but at BMI ≥ 40 kg/m², more rehabilitation and monitoring are recommended because of more patellar radiolucencies, poorer hamstring and quadriceps conditioning, and more patellofemoral symptoms. There are limitations of this study. The multivariate analysis is limited by a limited availability of information on potential confounding factors and by a cross-sectional nature of the sample. Furthermore, there should be a long-time follow-up of our study population. The associated data should also be part of future publications. We conclude that both the primary hip and knee arthroplasty can be performed in all stages of obesity with

Table 10  Relationships between preferred prosthesis type, age at total hip arthroplasty, Harris Hip Score, body mass index, stages of overweight/obesity and gender

| BMI (kg/m²)                  | 25–29.9 total | 30–34.9 total | 35–39.9 total | ≥ 40 total |
|-----------------------------|---------------|---------------|---------------|-----------|
| Femoral fracture            | 8             | 2             | 1             | 1         |
| Femoral perforation         | 2             | 1             | 0.1           |           |
| Trochanteric fracture       | 4             | 0.1           |               |           |
| Acetabular fracture         |               | 1             | 0.1           |           |
| Acetabular perforation      | 11            | 0.3           | 6             | 0.3%      |
| Vascular lesion             | 1             | 0.0%          |               |           |
| Other complications         | 1             | 0.0%          | 2             | 0.1%      |

Table 11  Surgical complications in total hip arthroplasty

| BMI (kg/m²)                  | 25–29.9 total | 30–34.9 total | 35–39.9 total | ≥ 40 total |
|-----------------------------|---------------|---------------|---------------|-----------|
| Femoral fracture            | 4             | 0.1%          | 2             | 0.1%      |
| Femoral perforation         | 3             | 0.1%          | 1             | 0.1%      |
| Rupture of the patellar tendon| 2            | 0.1%          | 1             | 0.1%      |
| Vascular lesion             | 1             | 0.0%          |               |           |
| Wound healing disorders     | 3             | 0.1%          | 4             | 0.2%      |

Table 12  Surgical complications in total knee arthroplasty

| BMI (kg/m²)                  | 25–29.9 total | 30–34.9 total | 35–39.9 total | ≥ 40 total |
|-----------------------------|---------------|---------------|---------------|-----------|
| Femoral fracture            | 4             | 0.1%          | 2             | 0.3%      |
| Femoral perforation         | 3             | 0.1%          | 1             | 0.1%      |
| Vascular lesion             |               | 0.0%          |               |           |
| Other complications         | 3             | 0.1%          | 4             | 0.2%      |
a relatively low perioperative risk. A higher BMI leads to an endoprosthetic joint replacement at earlier times, which, however, is only carried out at significantly lower levels of joint function.

**COMMENTS**

**Background**

The prevalence of overweight patients is steadily increasing in the general population. It is known that obesity has a negative influence on the formation of osteoarthritis. An increased body mass index leads to an increased risk of needing a joint replacement.

**Research frontiers**

To the knowledge, there is no study that evaluated the influence of the respective stage of obesity in a monocentric setting with large number of cases.

**Innovations and breakthroughs**

Six thousand and seventy-eight patients with a body mass index (BMI) $\geq 25$ kg/m$^2$ were treated with a primary total hip arthroplasty (THA) or total knee arthroplasty (TKA). Age decreased significantly ($P < 0.001$) by increasing obesity in both the THA and TKA. Harris Hip Score (HHS) and Hospital for Special Surgery Score (HSS) were at significantly lower values at the time of treatment in the super-obese population ($P < 0.001$). Distribution patterns of the type of endoprostheses used changed with an increasing BMI. Peri- and postoperative complications were similar in form and quantity to those of the normal population.

**Applications**

We conclude that both the primary hip and knee arthroplasty can be performed in all stages of obesity with a relatively low perioperative risk. A higher BMI leads to an endoprosthetic joint replacement at earlier times, which, however, is only carried out at significantly lower levels of joint function. Good preparation is indispensable.

**Terminology**

According to the classification of the World Health Organization overweight is defined as BMI 25-29.9 kg/m$^2$, stage I obesity is defined as BMI 30-34.9 kg/m$^2$, stage II obesity is defined as 35-39.9 kg/m$^2$ and stage III obesity is defined as BMI $\geq$ 40 kg/m$^2$. HHS and Hospital for HSS are used to measure function in patients suffering from osteoarthrosis of the hip or the knee, respectively.

**Peer review**

This retrospective study, conducted at a single medical center with high volume of total joint arthroplasty, showed some interesting findings. The study was well conducted with detailed data analysis. The conclusion is validated.

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