

# The Influence of Obesity on the Complication Rate and Outcome of Total Knee Arthroplasty

## A Meta-Analysis and Systematic Literature Review

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**Background:** The increase in the number of individuals with an unhealthily high body weight is particularly relevant in the United States. Obesity (body mass index  $\geq 30$  kg/m<sup>2</sup>) is a well-documented risk factor for the development of osteoarthritis. Furthermore, an increased prevalence of total knee arthroplasty in obese individuals has been observed in the last decades. The primary aim of this systematic literature review was to determine whether obesity has a negative influence on outcome after primary total knee arthroplasty.

**Methods:** A search of the literature was performed, and studies comparing the outcome of total knee arthroplasty in different weight groups were included. The methodology of the included studies was scored according to the Cochrane guidelines. Data extraction and pooling were performed. The weighted mean difference for continuous data and the weighted odds ratio for dichotomous variables were calculated. Heterogeneity was calculated with use of the  $I^2$  statistic.

**Results:** After consensus was reached, twenty studies were included in the data analysis. The presence of any infection was reported in fourteen studies including 15,276 patients ( $I^2$ , 26%). Overall, infection occurred more often in obese patients, with an odds ratio of 1.90 (95% confidence interval [CI], 1.46 to 2.47). Deep infection requiring surgical debridement was reported in nine studies including 5061 patients ( $I^2$ , 0%). Deep infection occurred more often in obese patients, with an odds ratio of 2.38 (95% CI, 1.28 to 4.55). Revision of the total knee arthroplasty, defined as exchange or removal of the components for any reason, was documented in eleven studies including 12,101 patients ( $I^2$ , 25%). Revision for any reason occurred more often in obese patients, with an odds ratio of 1.30 (95% CI, 1.02 to 1.67).

**Conclusions:** Obesity had a negative influence on outcome after total knee arthroplasty.

**Level of Evidence:** Prognostic Level II. See Instructions for Authors for a complete description of levels of evidence.

The prevalence of obesity in industrialized and emerging countries is reaching epidemic proportions<sup>1</sup>. The increase in the population of individuals with a high body weight is particularly relevant in the United States<sup>2</sup>. Obesity is a well-documented risk factor for the development of osteoarthritis<sup>3-5</sup>. A body mass index (BMI) of  $\geq 30$  kg/m<sup>2</sup> is generally categorized as obese, but the threshold value for the BMI that accurately separates individuals who are at high or low risk of developing osteoarthritis has not been definitely established. Treatment of arthritis is initially nonoperative, but total joint

arthroplasty often becomes necessary if the disease progresses. Consequently, the performance of joint arthroplasty in obese individuals has increased in the last decades.

Although obesity appears to have a negative influence on the complication rate and the survival of total knee arthroplasty, we are aware of no definitive proof in the literature. Amin et al.<sup>6</sup> observed that obesity did not influence the five-year outcome of total knee arthroplasty. Benjamin et al.<sup>7</sup> reported similar complication rates for total knee arthroplasty in obese compared with nonobese individuals in a study that included

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316 patients. A large study of 8892 patients revealed no significant difference between patients who were obese and those who were nonobese with regard to survival and complications<sup>8</sup>, and several smaller studies also failed to show a difference between these two groups<sup>9-11</sup>. Chesney et al.<sup>12</sup> and Foran et al.<sup>13,14</sup> described a trend toward a greater number of complications in obese patients. Only a few studies have reported significantly more complications in obese compared with nonobese patients<sup>15,16</sup>. The fact that several studies have reported trends toward more complications could indicate that the power of individual studies is too low. Thus, the present meta-analysis of the results of all studies compared the outcome and survival of primary total knee arthroplasty between two BMI groups,  $<30$  and  $\geq 30$  kg/m<sup>2</sup>. The primary aim of this systematic review of the literature was to determine whether obesity had a negative influence on patient outcome after primary total knee arthroplasty.

### Materials and Methods

Our search strategy followed the recommendations of the Cochrane collaboration<sup>17</sup>. The databases of PubMed/MEDLINE, the Cochrane Database of Systematic Reviews, and Embase from 1970 to 2009 were searched for publications on obesity and total knee arthroplasty. The search terms “arthroplasty,” “knee,” “weight,” “BMI,” and “obesity” were used. Furthermore, the reference lists of retrieved publications were checked manually for additional studies that potentially met the inclusion criteria but had not been found by the electronic search. Two investigators (G.M.M.J.K. and D.H.) independently reviewed the literature to identify relevant articles for full-text review. The reviewers independently applied the criteria described above and below to the full text of these articles to select articles for inclusion in this review. The reviewers are orthopaedic surgeons who are familiar with total knee arthroplasty surgery and are also trained and experienced in performing meta-analyses. Disagreement regarding the search was resolved by consensus, with arbitration by a third author (J.A.M.B.) if differences remained.

A study was included if it represented a comparative trial in which the outcome of primary total knee arthroplasty was reported according to BMI. Studies involving all types of cemented and noncemented total knee prosthesis designs were included. Review articles, expert opinions, surgical techniques, and abstracts from scientific meetings were excluded. Only articles written in English were included. Studies were not blinded by author, affiliation, or source.

Our primary research question was to determine whether the outcome of primary total knee arthroplasty was influenced by BMI. Outcomes of interest were infection (deep, superficial, or any), revision for infection, aseptic loosening, hematoma, venous thromboembolism, perioperative fracture, nerve damage, tendon or ligament rupture, Knee Society Score<sup>18</sup>, Knee Society function subscore, and range of knee motion.

The methodology of the randomized clinical trials and controlled clinical trials was independently assessed by two reviewers (E.S. and D.D.). First, the methodology was assessed with use of the list of criteria recommended by the Cochrane Collaboration Back Review Group<sup>19</sup>, with adaptation of the bias criteria for observational studies. Second, the criteria listed on *The Journal of Bone and Joint Surgery* web site, which are an adaptation of the criteria developed by the Centre for Evidence-Based Medicine (Oxford, United Kingdom), were used to define the level of evidence. Disagreement was resolved by group assessment.

The data from the included studies were extracted by two reviewers (G.M.M.J.K., D.H.), with use of a data extraction tool tested in a pilot study and were verified by a third reviewer (W.D.). The available data from the selected studies were then pooled with use of the review manager software from the Cochrane collaboration.

The weighted mean difference and accompanying 95% confidence interval (CI) were calculated for continuous variables, and the weighted odds ratio and 95% CI were calculated for dichotomous variables. If a continuous

variable was reported with a range, the standard deviation was calculated with use of the method described by Walter and Yao<sup>20</sup>. The heterogeneity of the included studies was calculated with use of the I<sup>2</sup> statistic, which describes the percentage of variation across studies that is due to heterogeneity rather than chance<sup>21</sup>. Assessment of heterogeneity in a meta-analysis is crucial because the presence or absence of true heterogeneity (variability among studies) can affect the statistical model that should be used. An I<sup>2</sup> value of 0% can be considered to represent no heterogeneity; 25%, low; 50%, moderate; and 75%, high. For an I<sup>2</sup> value of up to 50%, it is correct to use a fixed-effects model when pooling the data; for a higher heterogeneity, a random-effects model should be used. We also assessed heterogeneity by means of a chi-square analysis, with  $p < 0.1$  considered suggestive of statistical heterogeneity.

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### Results

A flow diagram showing the selection of the studies is shown in Figure 1. After consensus was reached, twenty studies were included for data analysis. The baseline characteristics and methodology of the included trials are summarized in the Appendix<sup>6-16,22-30</sup>.

Data regarding the presence of any infection were extracted from the studies in which this outcome was reported; in addition, deep and superficial infections were analyzed separately in studies

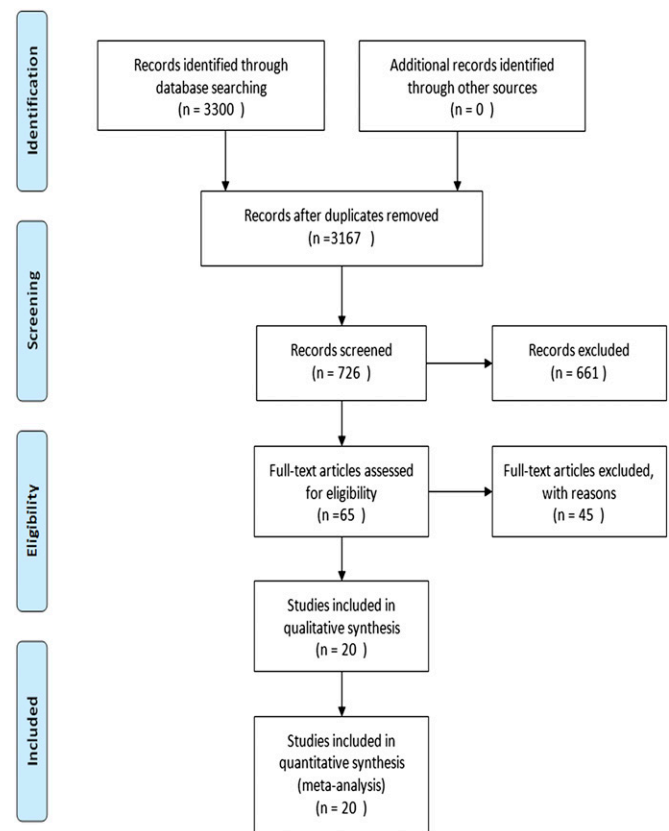


Fig. 1  
Flowchart showing identification of the included studies.

TABLE I Results of the Meta-Analysis

Outcome	No. of Patients	No. of Events	Heterogeneity, I <sup>2</sup> (%)	Odds Ratio or Difference (95% CI)
Any infection	15,276	253	26	1.90 (1.46 to 2.47)
Superficial infection	4905	126	6	2.17 (1.47 to 3.13)
Deep infection	5061	45	0	2.38 (1.28 to 4.55)
Any revision	12,101	277	25	1.30 (1.02 to 1.67)
Revision for infection	13,686	75	0	0.98 (0.61 to 1.56)
Revision for aseptic loosening	10,207	135	0	1.23 (0.87 to 1.75)
Intraoperative fracture	10,363	17	0	1.03 (0.38 to 2.78)
Nerve injury	10,217	12	0	0.89 (0.28 to 2.86)
Intraoperative tendon/ligament rupture	10490	16	29	0.97 (0.35 to 2.70)
Venous thromboembolism	13,459	106	0	1.19 (0.78 to 1.82)
Knee Society Score	670	—	0	3.23 (1.57 to 4.90)*
Knee Society function subscore	1302	—	84	

\*A positive difference indicates a higher score in the nonobese group.

that distinguished between them. The presence of any infection was reported in fourteen studies including 15,276 patients; these studies had a low heterogeneity, with an I<sup>2</sup> of 26% (Fig. 2). Overall, infection occurred more often in obese patients, with an odds ratio of 1.90 (95% CI, 1.46 to 2.47). Superficial infection was reported separately in nine studies including 4905 patients; the heterogeneity among these studies was low, with an I<sup>2</sup> of 6%. Superficial infection occurred more often in obese patients, with an odds ratio of 2.17 (95% CI, 1.47 to 3.13). Deep infection

requiring surgical debridement was reported separately in nine studies including 5061 patients; no heterogeneity was found among these studies (I<sup>2</sup>, 0%). Deep infection occurred more often in obese patients, with an odds ratio of 2.38 (95% CI, 1.28 to 4.55) (Table I).

Revision of the total knee arthroplasty, defined as exchange or removal of the components for any reason, was documented in eleven studies including 12,101 patients. Heterogeneity among these studies was low, with an I<sup>2</sup> of 25%. Revision for any reason

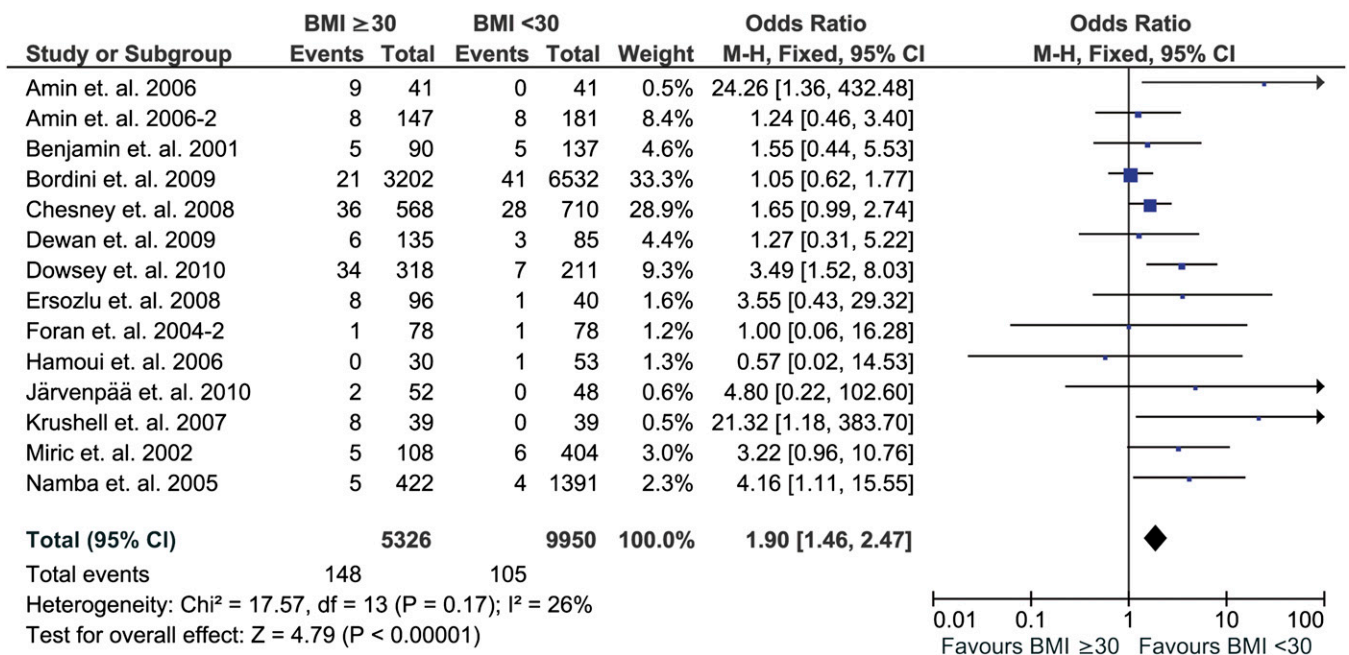


Fig. 2

Overall infection rate after total knee arthroplasty according to body mass index (BMI, in kg/m<sup>2</sup>). M-H = Mantel-Haenszel, CI = confidence interval, and df = degrees of freedom.

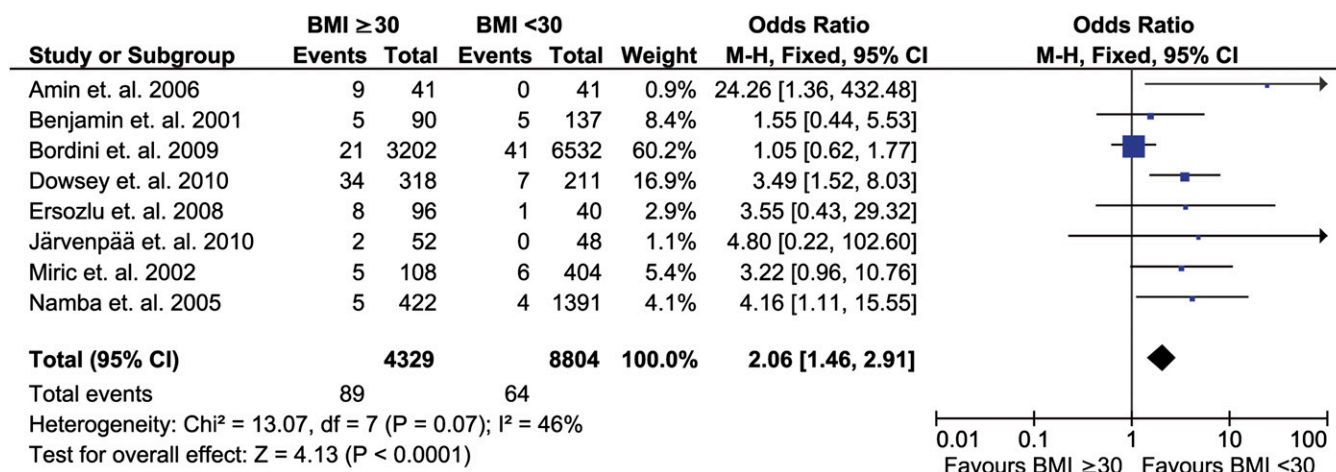


Fig. 3

Overall infection rate after total knee arthroplasty according to body mass index (BMI, in kg/m<sup>2</sup>) in studies with short-term follow-up. M-H = Mantel-Haenszel, CI = confidence interval, and df = degrees of freedom.

occurred more often in obese patients, with an odds ratio of 1.30 (95% CI, 1.02 to 1.67). With the numbers available, the revision rate did not differ significantly between obese and nonobese patients when revision surgery for infection and revision for aseptic loosening were analyzed separately (Table I).

The complications that occurred during the surgical procedure were mentioned in only four studies. The low heterogeneity among these studies allowed pooling of the results and, on the basis of the numbers, no significant differences were found in the occurrence of intraoperative fracture, nerve injury, or tendon or ligament rupture. This lack of difference may be the result of the small number of events in these studies (Table I).

The main postoperative complication not related to the implant was the occurrence of a clinically manifest deep venous thromboembolism and/or pulmonary embolism. Nine studies

with a total of 13,459 patients reported on this complication, and the results were pooled since no heterogeneity among the studies was found ( $I^2$ , 0%). This complication rate did not differ significantly between obese and nonobese patients (odds ratio, 1.19; 95% CI, 0.78 to 1.82).

The most commonly reported functional outcomes in the studies were the Knee Society Score and Knee Society function subscore. Nine studies including 670 patients reported the Knee Society Score for obese and nonobese patients. After pooling of the studies, which had an  $I^2$  of 0%, this score showed a difference of 3.23 points (95% CI, 1.57 to 4.90 points) in favor of the nonobese patients; however, the clinical significance of such a small difference on a scale of 0 to 100 can be questioned. The Knee Society function subscore was reported for a greater number of patients, but it could not be pooled because of the high heterogeneity ( $I^2$ , 84%).

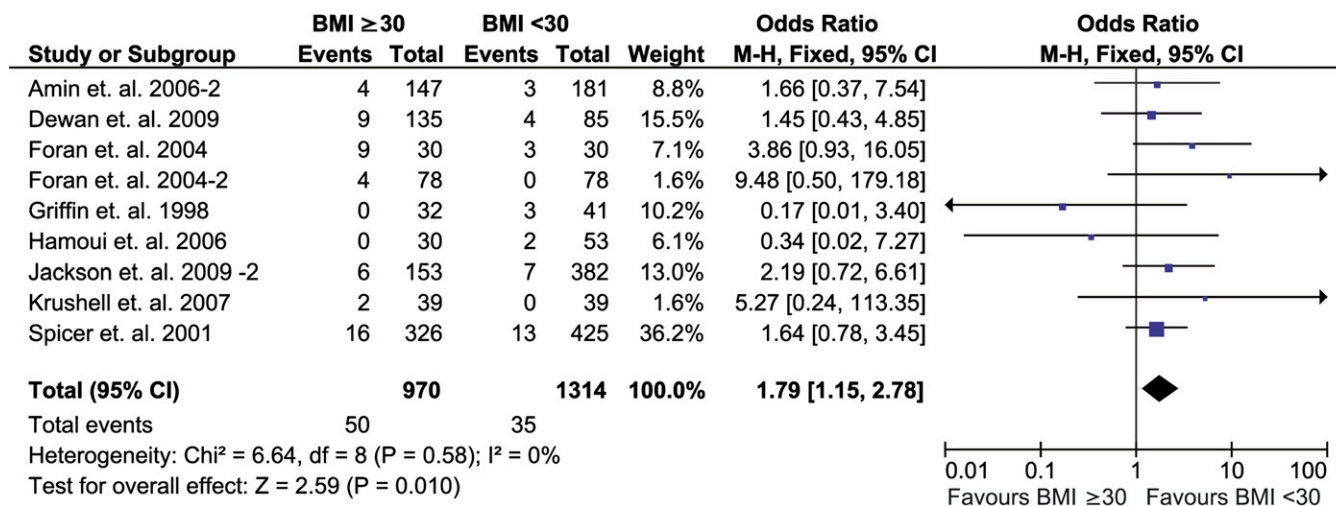


Fig. 4

Overall revision rate after total knee arthroplasty according to body mass index (BMI, in kg/m<sup>2</sup>) in studies with follow-up of more than five years. M-H = Mantel-Haenszel, CI = confidence interval, and df = degrees of freedom.



Subgroup analyses of certain outcomes were performed for short or long-term follow-up. The overall infection rate was analyzed for studies that reported the short-term outcome, since infection may be better documented in such studies. The eight studies including 13,133 patients that reported short-term results indicated a twofold greater infection rate in the obese patients (odds ratio, 2.06; 95% CI, 1.46 to 2.91); the heterogeneity was moderate ( $I^2$ , 46%) (Fig. 3). In addition, revision for any reason was analyzed for studies with more than five years of follow-up, since the number of revisions was expected to increase with elapsed time. The nine studies including 2284 patients that fulfilled this criterion indicated the revision rate to be twice as high in the obese patients in the long term (odds ratio, 1.79; 95% CI, 1.15 to 2.78) ( $I^2$ , 0%) (Fig. 4).

### Discussion

The aim of our systematic review of the literature was to show whether obesity leads to a worse outcome following total knee arthroplasty. Our results showed that patients with a BMI of  $\geq 30$  kg/m<sup>2</sup> had more infections and a higher revision rate compared with patients with a BMI of  $< 30$  kg/m<sup>2</sup>. Total knee arthroplasty in obese patients was therefore associated with higher risks in both the short and the long term. We believe that obese patients should be informed of the above-mentioned risks and should be advised to lose weight. Many patients will fail to achieve this goal without professional help, so we refer obese patients with osteoarthritis to a multidisciplinary obesity outpatient clinic. If this approach fails to result in weight loss, the patient at least benefits from a thorough analysis of existing comorbidity and optimization of his or her medical condition. We do not withhold a total knee arthroplasty from these patients, but we inform them extensively regarding the risk that their obesity poses with regard to this procedure.

The study by Bordini et al.<sup>8</sup> may have introduced a bias in our meta-analysis of infection. This study could have influenced the outcome because the study population was large (8892 patients) and the infection rate was dramatically low, with four superficial infections and fifty-eight revisions for infection. The superficial infection rate was only 0.04%, and the rate of any infection (calculating revision for infection as representing deep infection) was 0.6%. We performed an additional analysis in which this study was omitted from the calculation of the infection rate in the studies with short-term outcome. This did alter the results of the meta-analysis, with the obese group scoring worse for infection risk, with an odds ratio of 3.57 (95% CI, 2.17 to 5.88). Heterogeneity remained low, with an  $I^2$  of 0%.


It is reasonable to assume that obese patients have more comorbidities than nonobese patients, and that this is theoretically the reason for the higher complication rates in the obese group. However, obese patients without other comorbidities do not have the same risk as obese patients with other comorbidities. The choice of the threshold for the BMI value was based on a consensus that 30 kg/m<sup>2</sup> represents the cutoff between obese and nonobese individuals. We chose to use 30 kg/m<sup>2</sup> as the threshold even though a BMI of  $\geq 25$  kg/m<sup>2</sup> in-

dicates that an individual is overweight. A BMI of 25 kg/m<sup>2</sup> to  $< 30$  kg/m<sup>2</sup> is becoming more common and is starting to be considered as more or less normal. Not all of the included studies used a BMI value of 30 kg/m<sup>2</sup> as the threshold for obesity. Some used a threshold of 35 kg/m<sup>2</sup>, although no justification for the use of that threshold was provided<sup>27,29</sup>. To assess the effect of weight on the outcome, it would be best to use BMI as a continuous variable in the analysis.

Obtaining Level-I evidence for the impact of morbid obesity on the outcome of total knee arthroplasty is difficult; a highest-quality study cannot be performed since blinding is only partially possible. We chose to include all comparative studies in this systematic review since that represented the best evidence available at present. Differentiation between retrospective and prospective trials can be difficult because many authors present a study with prospective data collection and retrospective analysis of the data as being prospective in design. Scoring of the methodology, however, showed that the studies included in this review were comparable and that pooling them was therefore justifiable.

We conclude that obesity had a negative influence on the outcome of patients treated with total knee arthroplasty, with more short-term complications and poorer long-term outcome compared with nonobese patients.

### Appendix

 Tables summarizing the methodological validity and characteristics of the included studies are available with the online version of this article as a data supplement at [jbjs.org](http://jbjs.org). ■

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