

3TITLE PAGE

Title: Does bariatric surgery prior to total hip or knee replacement reduce post-operative complications and improve clinical outcomes for obese patients? Systematic review and meta-analysis.

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Author Contributions

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Literature search strategy: TS, TA

Data extraction and critical appraisal: TS, TA

Analysis of data: TS, TA, CH, AM

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Guarantor: TS

ABSTRACT

Aims: To determine whether, based on the current literature, bariatric surgery prior to total hip (THR) or total knee replacement (TKR) reduces complication rates and improves outcome following arthroplasty.

Materials and Methods: Systematic literature search was undertaken of published and unpublished databases on the 5th November 2015. All papers reporting studies comparing people who had undergone bariatric surgery versus not prior to THR or TKR were included. Each study was assessed using the Downs and Black appraisal tool. A meta-analysis of risk ratios (RR) and 95% confidence intervals was performed to determine the incidence of complications including wound infection, deep vein thrombosis (DVT), pulmonary embolism (PE), joint revision and mortality.

Results: From 156 potentially studies, five papers were eligible. In total 23,348 (657 bariatric surgery, 22,691 non-bariatric surgery) participants were analysed. The evidence-base was moderate in quality. There was no statistically significant difference in outcomes such as superficial wound infection (RR: 1.88), deep wound infection (RR: 1.04), DVT (RR: 0.57), PE (RR: 0.51), joint revision (RR: 1.24) or mortality (RR: 1.25) between the two groups.

Conclusions: For the majority of peri-operative outcomes, bariatric surgery prior to THR or TKR does not significantly reduce complication rates or improve clinical outcomes.

Clinical Relevance: This study questions the previous notion that bariatric surgery prior to joint replacement may improve clinical outcomes for people who are obese or morbidly obese.

Keywords: Joint replacement; obesity; gastric bypass; gastric band; wound; function

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INTRODUCTION

Osteoarthritis is a leading cause of musculoskeletal disability and reduced quality of life in adults.¹ Joint replacement (or arthroplasty) is the surgical option for end-stage osteoarthritis when symptom management with conservative strategies is insufficient.²

Obesity is considered a major problem facing UK public health services.³ Obesity is defined using body mass index (BMI). People with a BMI of 20 kg/m² to 30 kg/m² are considered 'normal' body mass, 30 kg/m² to 40 kg/m² are categorised as obese, and greater than 40 kg/m² are considered morbidly obese.⁴ Approximately 62% of the UK population have a BMI of 30 or over.³

People with osteoarthritis have been acknowledged to be of greater risk of weight gain and higher BMI due to reduced physical activity.⁵ Surgical intervention for people who are obese may be associated with increased risk of complications such as deep and superficial wound infection, myocardial infarction (MI) and stroke.⁶⁻⁸ Furthermore previous papers have acknowledged that people who are obese have a poorer clinical outcome after hip or knee replacement.^{9,10}

To address these differences in outcomes and perceived post-operative complications, some arthroplasty candidates have undergone bariatric surgery procedures prior to their total hip (THR) or total knee replacement (TKR).¹¹ Such procedures have included gastric bypass, sleeve gastrectomy, stomach partition using staples and gastric balloon insertion. The alternative to surgical interventions has been for such individuals to receive dietary advice, psychological support on behaviour change interventions and physical activity interventions to promote compliance to long-term weight loss strategies.^{12,13} Previous reviews have investigated the clinical outcomes of each of these interventions for people with hip or knee osteoarthritis.^{14,15} These have reported a significant greater improvement in pain, function and stiffness in people following bariatric surgery compared to those not offered bariatric surgery. However no systematic reviews have been undertaken assessing whether there is a difference in outcomes (peri-operative and longer-term) between those who receive bariatric surgery compared to those who do not prior to THR or TKR. The purpose of this study was to answer this question based on the current evidence-base.

MATERIALS AND METHODS

Search Strategy

A primary search was performed of the electronic published literature databases EMBASE, AMED, CINAHL, MEDLINE, and the Cochrane Registry of Clinical Trials. A search was also performed of unpublished literature databases including OpenGrey, clinicaltrials.gov, the WHO clinical trial registry, the ISRCTN and the NIHR trial portfolio. The search strategy was modified for each individual database (**Supplementary Table 1**). All databases were reviewed from their inception to the 5th November 2015. The reference lists were reviewed of all potentially eligible studies and review papers identified on the preliminary search. Finally, the corresponding authors of all included studies were contacted and asked to review the results and declare whether any additional papers should be included.

Eligibility Criteria

All studies assessing outcomes of people who were determined obese or morbidly obese and who underwent any form of bariatric surgery before THR or TKR compared to people who were obese or morbidly obese and did not receive bariatric surgery before THR or TKR were included. All study designs comparing these two groups were included. We therefore included randomised and non-randomised controlled trials. Bariatric surgical interventions included gastric band, gastric bypass, sleeve gastrectomy, stomach partitioning using staples and gastric balloon insertion with or without a behaviour and dietary intervention. We included all papers irrespective of age, source or language of publication.

Study Identification

The titles and abstracts of all search results were independently reviewed by two reviewers (TS, TA) against the eligibility criteria. The full-texts of all citations which were deemed potentially eligible were obtained. These were then re-reviewed against the eligibility criteria. If there was disagreement between the two reviewers, this was resolved through discussion or adjudicated by a third reviewer (AM).

Outcome Measures

The primary outcome was the frequency of post-operative complications within the initial 12 month post-operative period. Potential post-operative complications included superficial and deep wound infection, deep vein thrombosis (DVT), pulmonary embolism (PE), joint revision or mortality. Secondary outcomes included inpatient readmission, clinical outcomes such as the Oxford Hip Score¹⁶ or Oxford Knee Score¹⁷, length of hospital stay, pain score and patient-reported quality of life measured with tools such as the EQ-5D-5L.¹⁸ Secondary outcomes were measured to 24 months post-operatively. Outcomes were analysed as either inpatient, shorter-term (hospital discharge to 90 days), intermediate-term (three months to six months), and longer-term (six months onwards).

Data Extraction

Data were collected by one reviewer (TA) and verified by a second (TS). Where disagreement in data collection occurred, this was resolved through discussion. Data extracted included: cohort mean age, gender mix, surgical procedure, American Society of Anaesthesiologists (ASA) score, BMI at arthroplasty procedure, and the outcomes of interest.

Quality Assessment

All included studies were assessed with quality assessment tools. As all the studies were non-randomised controlled trials, the Down and Blacks¹⁹ tool was adopted. Each paper was reviewed by one reviewer (TA) and verified by a second (TS). Cases of disagreement between the two reviewers were resolved through discussion and adjudicated by a third reviewer (AM).

Data Analysis

The data extraction tables were reviewed for study heterogeneity. In cases where there was study heterogeneity in respect to participant characteristics, bariatric surgery interventions within the cohorts, outcome measures and study design, a narrative review of the findings was undertaken. Where these study characteristics were homogeneous, a meta-analysis was undertaken. Statistical heterogeneity was assessed using the inconsistency-value (I^2) and Chi-squared tests. In cases where I^2 was $\leq 20\%$ and Chi-squared equated to $p \leq 0.10$, a fixed-effects model meta-analysis was undertaken. When these were not satisfied, a random-effects meta-analysis was undertaken. For all continuous outcomes e.g. Oxford Knee Score, patient-reported quality of life, length of stay and

pain, the mean difference was calculated with 95% confidence intervals (CI). For all dichotomous outcomes such as complications or readmission, a relative risk (RR) was estimated with 95% confidence intervals. For all analyses, $p < 0.05$ denoted statistical significance.

Subgroup analyses which were planned *a priori* included comparison of the intervention to control group on clinical outcomes stratified by age (less than 65 years versus 66 years and over), BMI group (less than or equal to BMI 40 versus BMI greater than 40), by arthroplasty type (THR versus TKR) and by duration of arthroplasty from bariatric surgery (e.g. TKR within or longer than two years). All analyses were undertaken by two reviewers (TS, TA) using Revman Version 5.3 (Review Manager, RevMan). Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014).

The analysis for each outcome was evaluated using the GRADE approach by two reviewers (TA, TS).²⁰ This approach evaluates the quality of evidence for each analysis undertaken (i.e. the body of the literature forming that particular analysis as opposed to the whole evidence irrespective of whether it was used in an analysis or not). Using this, the quality of evidence was categorised into four possible levels: high, moderate, low or very low quality.²⁰

RESULTS

Search Strategy

A total of 156 citations were identified from the search strategy. From these, five were deemed eligible (**Figure 1**). These were all non-randomised controlled trials.

Characteristics of Included Studies

A summary of the characteristics of the included studies is presented in **Table 1**. In total 23,348 participants were included in this analysis. A total of 6632 males and 16,572 females were recruited with a mean age of 63.2 years (range: 53 years²¹ to 64 years²²). Kulkarni et al²¹ did not present data on the number of males and females in their cohort. The analysis cohort considered of 657 participants who received bariatric surgery and 22,691 who did not receive bariatric surgery. No studies documented the type of bariatric surgery procedure which was undertaken in their cohorts.

Total knee replacement was performed in 20,636 people whilst 2709 underwent THR; three underwent hip resurfacing in Kulkarni et al's²¹ cohort. The mean BMI at arthroplasty was 36.1 kg/m² in the bariatric cohort and 42.9 kg/m² in the non-bariatric cohort. Two studies did not present the BMI data for their cohort.^{21,23} Two studies presented the data as classified by whether participants had received bariatric surgery within or longer than two years before their arthroplasty procedure.^{22,24} The other three studies did not document the duration between bariatric surgery and arthroplasty for their cohorts.

Quality Assessment

The quality of the research was largely moderate to good (**Table 2**). Recurrent strengths presented across the five studies included clearly stating the study aims and objectives, participant characteristics, surgical procedures and potential confounders to influence the outcome. All five papers clearly presented the findings of their results and presented both point and variance data for clinical scores and adverse events.

The evidence-base however presented with a number of important limitations. Firstly, one study did not present its data using probability values and did not adjust for different lengths of follow-up.²² Due to their retrospective nature, none of the studies randomised participants to group allocation, and it was not logistical to blind participants to whether or not they received bariatric surgery. Three studies recruited both cases and controls at the same time.²¹⁻²³ Finally no studies performed a power calculation to determine whether they analysed sufficient numbers of participants to detect a statistically significant difference.

Meta-Analyses

A summary of the results of the meta-analyses are presented in **Table 3**.

Primary Outcome

All five studies presented data on post-operative complications at 30 days post-operatively.²¹⁻²⁵ On meta-analysis, there was no significant difference between those who underwent bariatric surgery to those that did not for superficial wound infection (RR: 1.88, 95% CI: 0.95 to 3.73), deep wound infection (RR: 1.04; 95% CI: 0.65 to 1.66), DVT (RR: 0.57, 95% CI: 0.13 to 2.44) and PE (RR:

0.51, 95% CI: 0.03 to 8.26). There was no statistically significant difference in re-operation rates for joint revision from 12 months²² to 14 years²⁴ post-arthroplasty (RR: 1.24, 95% CI: 0.75 to 2.05; p=0.40) or mortality (RR: 1.25, 95% CI: 0.16 to 9.89).

There was however a significant difference in favour of those who received pre-arthroplasty bariatric surgery for the assessment of post-operative infection requiring or not-requiring irrigation and draining.^{21,23} There was a statistically significant greater risk of wound infection (with or without irrigation and drainage) for the non-bariatric surgery group (RR: 0.36, 95% CI: 0.15 to 0.90; p=0.03; N=11656; I²: 0%; p=0.86; **Figure 2**).

One study assessed the difference in post-operative THR prosthesis dislocation between those who underwent bariatric surgery pre-arthroplasty compared to non-bariatric surgery.²¹ They reported no statistically significant difference between the intervention arms (RR: 1.18, 95% CI: 0.11 to 12.68; N=143)

Two studies reported the frequency of complications at 90-days follow-up.^{22,24} There was no significant difference for this outcome between those who underwent compared to those who did not undergo bariatric surgery pre-arthroplasty (RR: 0.63, 95% CI: 0.32 to 1.26; N=11328; I²: 0%; p=0.96).

Two studies presented data on inpatient readmission.^{21,22} On meta-analysis, there was no statistically significant difference between the bariatric versus non-bariatric surgery groups (RR: 0.57, 95% CI: 0.06 to 5.09, p=0.62, N=11346, I²: 74%, p=0.05).

These analyses on post-operative complications were assessed as ‘very low’ quality of evidence using the GRADE approach. Accordingly, there is very little confidence in the effect estimate due to inconsistency in results, imprecision and risk of bias.²⁰

Secondary Outcomes

Length of hospital stay was measured in two studies.^{21,22} There was insufficient data to analyse this outcome through meta-analysis. On narrative review there was no statistically significant difference between those who received bariatric compared to non-bariatric surgery pre-arthroplasty (p>0.05).

Two studies presented data on the frequency of post-operative blood transfusion with people following TKR.^{23,24} On meta-analysis, there was no statistically significant difference in requirement for post-operative blood transfusion between the two bariatric management cohorts (RR: 2.30, 95% CI: 0.23 to 23.05, p=0.48, N=11638, I²: 46%; p=0.17). On GRADE assessment, these findings were considered of 'low' quality due to risk of bias and imprecision. There is therefore limited confidence in the effect estimate, and the true estimate may be substantially different from the estimate of the effect.²⁰

No studies assessed pain scores, patient-reported quality of life, nor clinical outcomes with functional and patient-reported scoring systems such as the Harris Hip Score or the Oxford Hip or Knee Scores.

Subgroup Analyses

There was insufficient data to perform subgroup analyses by age and BMI category. However, there was sufficient data to perform subgroup analyses by duration of arthroplasty from bariatric surgery (i.e. TKR within or longer than two years). Based on this, there was no significant difference in the occurrence of deep wound infection (RR: 0.73, 95% CI: 0.09 to 5.81, p=0.76, N=257, I²: 0%, p=0.94), joint revision (RR: 0.91, 95% CI: 0.11 to 7.83, p=0.93, N=257, I²: 47%, p=0.17) or 90-day post-operative complications (RR: 0.43, 95% CI: 0.10 to 1.82, p=0.25, N=257, I²: 16%, p=0.27) for those who underwent TKR within or longer than two years post-bariatric surgery. As per the initial analysis, on GRADE assessment, these subgroup findings were considered of 'low' quality due to risk of bias and imprecision. There is therefore limited confidence in the effect estimate and the true estimate may be substantially different from the estimate of the effect.²⁰

DISCUSSION

The findings of this systematic review indicate that for the majority of outcomes there is no significant difference in the frequency of peri-operative complications and post-operative clinical outcomes between those who do compared to those who do not undergo bariatric surgical procedures prior to THR or TKR. Only overall medical complications (collectively assessed) and wound infection (requiring or not requiring irrigation and drainage) showed a significant risk ratio,

favouring the bariatric surgery group. Whilst the evidence-base was moderate in quality, the GRADE analysis determined that the analyses were 'low' or 'very low' quality, and therefore should be viewed with some caution. Nonetheless these findings are contrary to previous belief that bariatric surgery may be a valuable surgical option to reduce the risks of poor clinical outcome for people prior to arthroplasty procedure.

Whilst the non-bariatric surgery groups included in these analyses presented with higher BMI measurements pre-arthroplasty compared to the bariatric surgery groups, this difference ranged from 0kg/m^2 ²⁵ to 7.6kg/m^2 .²² Therefore the difference between groups on the principle causative factor (i.e. BMI) was of little difference in studies such as Martin et al.²⁵. Accordingly the difference in clinical outcomes between those people with high versus lower BMI may still be evident and undisputed by this analysis. There is also some confusion, due to poorly reporting previous non-bariatric interventions which these cohorts may have received, regarding alternative intervention which may have been used as weight reduction management strategies. Therefore the findings of this analysis may provide an insight as to whether or not bariatric surgery confers any additional benefit over and above non-surgical approaches to weight reduction. To determine this, future studies should ensure that previous non-surgical interventions which patients may have received, should be reported to determine how surgery relates to other weight management strategies.

There was insufficient data to compare the threshold for arthroplasty after bariatric surgery. Kulkarni et al²¹ described a minimum of six months following bariatric surgery as sufficient, assuming the level of obesity between their bariatric surgery and non-bariatric surgery groups was similar. Severson et al²⁴ and Inacio et al²² divided their groups into non-bariatric surgery, total joint arthroplasty (TJA) or TKR within two years of bariatric surgery, and TJA or TKR more than two years after bariatric surgery. The aim of performing bariatric surgery pre-arthroplasty has been to decrease a patient's BMI pre-surgery, however no mention has been made on whether a target BMI was stipulated pre-arthroplasty. Whilst three of the papers reported their group's BMI at the time of arthroplasty,^{22,24,25} this data was not provided for Werner et al²³ or Kulkarni et al²¹ studies. Whilst there appears limited indication that BMI post-bariatric surgery (or whether it is bariatric surgery itself) plays a role in arthroplasty outcomes, because of this omission from two studies^{21,23}, this uncertainty requires answering during future analyses as the evidence-base develops.

Whilst the evidence-base provided important data on complication and adverse event data, there is a paucity of clinical or health economic data on bariatric surgery versus non-bariatric surgery interventions prior to arthroplasty. Data from patient reported outcome measures and longer-term functional outcomes is also lacking to inform clinical decision-making on staged bariatric surgery. These are two very important omissions in the current evidence-base and are therefore research priorities to ensure that healthcare commissioners and health service users can be better informed on what could be the global health outcomes of these procedures pre-arthroplasty. A well-designed, pragmatic randomised controlled trial investigating the clinical and cost-effectiveness of bariatric surgery on THR and TKR outcomes with a sufficient follow-up period, is therefore warranted to better understand the recommendations (or not) of bariatric surgery prior to arthroplasty procedures for people with high BMI.

This study presented with three important limitations. Firstly, data from three papers^{22,23,25} were based on hospital and healthcare system datasets and registries, which were gathered through hospital coding systematic. Therefore errors in cataloguing and coding of procedures may have been a source of errors in subsequent data analyses. Secondly, whilst meta-analyses are partly aimed to overcome the issue statistical error through pooling homogenous datasets, due to such lower numbers of events of medical complications such as DVT, PE, MI and stroke, the findings of this analysis may therefore be affected by Type II error. Further analyses as datasets develop may therefore be indicated to assess for this potential limitation. Finally, this paper provides valuable data on outcomes principally within the first 18 months post-arthroplasty. This therefore provides insights into the potential differences in complications and recovery phases, but is insufficient when evaluating longer-term outcomes. Future trials should therefore analyse outcomes between those who undergo bariatric surgery and those who do not pre-arthroplasty to analyse the affect of this management approach on mid- to longer-term implant survival and revision procedures.

To conclude, bariatric surgery prior to THR or TKR may not significantly reduce the risk of complications post-arthroplasty. There is insufficient evidence to ascertain whether bariatric surgery prior to THR or TKR is cost-effective in relation to patient reported outcomes and quality of life as well as health utilisation in the longer-term. There is insufficient evidence to support or refute the use of bariatric surgical procedures for this population until the evidence-base in the form of prospective pragmatic cost-effectiveness randomised controlled trials is undertaken. Only then

will healthcare commissions, professionals and the public be sufficiently informed regarding the appropriateness of bariatric surgery prior to THR or TKR.

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FIGURE AND TABLE LEGENDS

Figure 1: A PRISMA flow-chart presenting the search strategy results

Figure 2: Forest plot of wound infection (requiring or not irrigation and drainage) for those who received bariatric surgery pre-operatively compared to non-bariatric surgery management prior to TKR or THR.

Table 1: Characteristics of included studies

Table 2: Summary of the critical appraisal results using the Downs and Black checklist for non-randomised studies

Table 3: Results of the meta-analyses

Supplementary Table 1: Search strategy for MEDLINE

Figure 1: A PRISMA flow-chart presenting the search strategy results

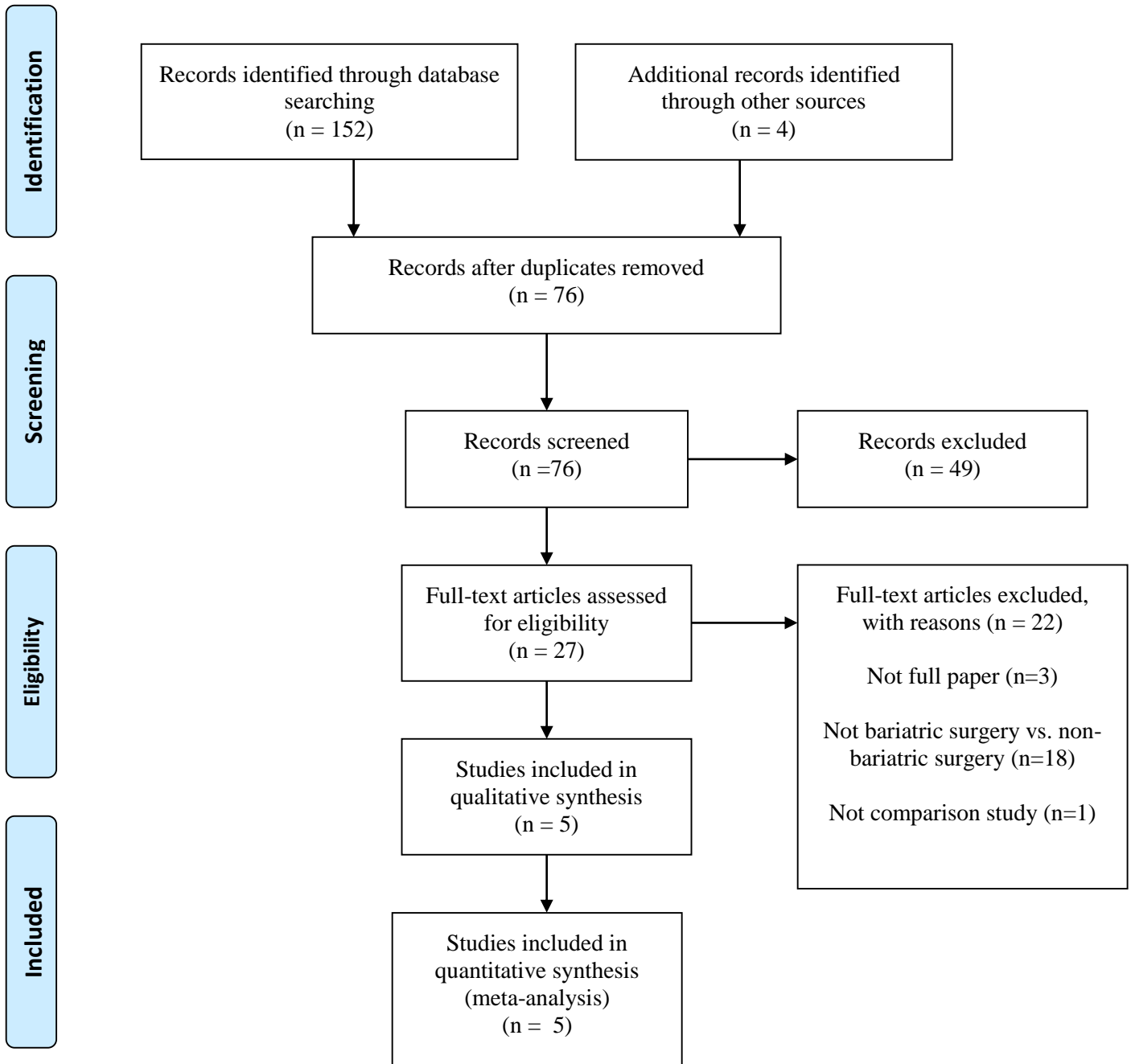


Figure 2: Forest plot of wound infection (requiring or not irrigation and drainage) for those who received bariatric surgery pre-operatively compared to non-bariatric surgery management prior to TKR or THR.

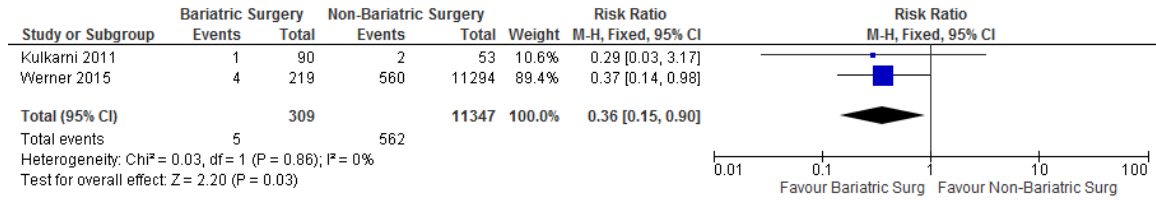


Table 1: Characteristics of included studies

Study Name	Inacio [22]	Kulkarni [21]	Martin [25]	Severson [24]	Werner [23]
N	11203	143	364	125	11513
N (Bariatric Surgery)	<2y: 102 >2y: 69	90	91	86	219
N (Non-Bariatric Surgery)	11032	53	273	39	11294
Gender (M/F)	3575/7628	ND	68/296	26/99	2963/8550
Mean age in years (SD/range)	BS (<2y): 57.0(6.8) BS (>2y): 59.9 (7.8) nBS: 63.8 (8.7)	BS: 57 nBS: 53	BS: 58.1 (8.0) nBS (high BMI): 57.4 (7.0) nBS (low BMI) 58.7 (7.0)	BS (<2y): 59.3 (7.5) BS (>2y) 59.0 (8.4) nBS: 55.5 (6.5)	ND
Frequency of surgical procedure (THR/TKR)	THR: 2653/ TKR: 8550	BS: 37 THR/ 53 TKR nBS: 19 THR/3 resurfacing; 31 TKR	TKR	TKR	TKR
Mean BMI in kg/m ² (SD/range)	BS (<2y): 32.4 (4.7) BS (>2y): 34.6 (6.2) nBS: 40.0 (4.4)	ND	BS: 37.2 (7.0); nBS (high BMI) 51.2 (9.0) nBS (low BMI) 37.2 (7.0)	BS (<2y): 37.9 (7.5) BS (>2y) 38.5 (9.8) nBS: 43.1 (6.3)	ND
ASA grade	BS (<2y): 1&2: 70; ≥3: 32 BS (>2y): 1&2: 38; ≥3: 31 nBS: 1&2: 4315; ≥3: 6598 Unknown: 119	ND	ND	ND	ND
Mean weight in kg (SD)	ND	ND	ND	BS (<2y): 104.1 (19.3) BS (>2y) 101.4 (22.6) nBS: 121.5 (19.3)	ND
Final Follow-up	12 months	18 months	BS: 3.9 years (SD 2) nBS (high BMI): 4.1 years (SD 2) nBS (low BMI): 4.1 years (SD 2)	Range: 22 months to 14 years	90 days

ASA - American Society of Anesthesiologists; BS – bariatric surgery; F – female; M – male; nBS – not bariatric surgery; ND – not documented; THR – total hip replacement; TKR – total knee replacement; SD- standard deviation

Table 2: Summary of the critical appraisal results using the Downs and Black checklist for non-randomised studies

	Inacio [22]	Kulkarni [21]	Martin [25]	Severson [24]	Werner [23]
1. Hypothesis/aims/objectives clearly stated	Y	Y	Y	Y	Y
2. Main outcome measures clearly described.	Y	Y	Y	Y	Y
3. Characteristics of patients/subjects clearly described	Y	Y	Y	Y	Y
4. Interventions of interest clearly described	Y	Y	Y	Y	Y
5. Distribution of principal confounders in each group clearly described	Y	Y	Y	Y	Y
6. Main findings clearly described	Y	Y	Y	Y	Y
7. Estimates of random variability in the data provided	Y	Y	Y	Y	Y
8. Important adverse events reported	Y	Y	Y	Y	Y
9. Characteristics of patients lost to follow-up described	UTD	UTD	UTD	Y	UTD
10. Actual probability values reported	N	Y	Y	Y	Y
11. Participants approached representative of entire population	Y	Y	Y	Y	Y
12. Participants recruited representative of entire population	Y	Y	Y	Y	Y
13. Staff, places and facilities representative of majority of population	Y	Y	Y	Y	Y
14. Blinding of study subjects	N	N	N	N	N
15. Blinding of assessors	N	N	N	N	N
16. Data based on data-dredging clearly stated	N/A	N/A	N/A	N/A	N/A
17. Adjustment of different length of follow-up or duration between case and control	N	Y	Y	Y	Y
18. Appropriate statistical tests used.	Y	Y	Y	Y	Y
19. Compliance to intervention reliable.	Y	Y	Y	Y	Y
20. Main outcome measure reliable and valid	Y	Y	Y	Y	Y
21. Intervention groups or case-controls recruited from same population	Y	Y	Y	Y	Y
22. Intervention groups or case-controls recruited at the same time.	Y	Y	N	N	Y
23. Study subjects randomized to the interventions	N	N	N	N	N
24. Was concealed randomization to allocation undertaken	N	N	N	N	N
25. Adequate adjustment made in the analysis of confounders	Y	UTD	Y	Y	Y
26. Patient losses accounted for.	Y	UTD	UTD	Y	UTD
27. Sufficiently powered cohort size	N	N	N	N	N

Y – Yes; N – No; UTD – Unable to determine

Table 3: Results of the meta-analyses

Outcome	Risk Ratio (95% CI)	P-value	N	Statistical heterogeneity (I²: Chi² p-value)
Superficial wound infection	1.88 (0.95, 0.37)	0.07	11,567	0%; 0.46
Deep wound infection	1.04 (0.65, 1.66)	0.88	22,841	0%; 0.83
Deep vein thrombosis	0.57 (0.13, 2.44)	0.45	11,710	0%; 1.00
Pulmonary embolism	0.51 (0.03, 8.26)	0.64	11,346	NE
Joint revision	1.24 (0.75, 2.05)	0.40	11,835	0%; 0.88
Mortality	1.25 (0.16, 9.89)	0.84	11,346	0%; 0.76
In-patient re-admission	0.57 (0.06, 5.09)	0.62	11,346	74%; 0.05*
Medical complication (collective)	0.54 (0.39, 0.74)	<0.01	11,781	0%; 0.74
Post-operative infection (with/without I&D)	0.36 (0.15, 0.90)	0.03	11,656	0%; 0.86
Post-operative blood transfusion	2.30 (0.23, 23.05)	0.48	11,638	46%; 0.17*
Complications within first 90 post- operative days	0.63 (0.32, 1.26)	0.19	11,328	0%; 0.96

* denotes that a random-effects analysis model was adopted; CI – confidence intervals; I² – inconsistency value; I&D – irrigation and drainage; N – number of cases

Supplementary Table 1: Search strategy for MEDLINE

1. Exp. Arthroplasty/
2. Joint replacement.tw.
3. Exp. Hip joint/
4. Exp. Knee/
5. Exp. Obesity/
6. Bariatri*.tw.
7. Obes*.tw.
8. Weight management.tw.
9. Weight loss.tw.
10. Exp. surgery/
11. Exp. Operation/
12. Operati*.tw.
13. Gastric band.tw.
14. Gastric bypass.tw.
15. Stomach staple.tw.
16. OR/1,2
17. OR/3,4
18. OR/6-9
19. OR/10-15
20. AND/16-19