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REVIEW

Does bariatric surgery improve outcomes of lower limb total joint arthroplasty?

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SUMMARY
Obesity is a strong modifiable risk factor for both the incidence and progression of lower limb osteoarthritis, particularly of the knee joint. Obesity is also associated with worse outcomes for total joint arthroplasty (TJA) of the hip and knee. Bariatric surgery (BS) is an increasingly common mode of weight loss. This systematic review shows no clear pattern of the impact of BS on lower limb TJA. Therefore, prophylactic BS prior to lower limb TJA to induce weight loss does not significantly impact postoperative complication rates.

Key Words
Bariatric surgery; total joint arthroplasty; obesity; osteoarthritis; outcomes

ABSTRACT

Background

Osteoarthritis is the leading indication for hip and knee arthroplasties in Australia. Obesity is a strong modifiable risk factor for both the incidence and progression of lower limb osteoarthritis, particularly of the knee joint. Obesity is also associated with worse outcomes for total joint arthroplasty (TJA) of the hip and knee. Bariatric surgery (BS) is an increasingly common mode of weight loss.

Aims

This study aims to determine if bariatric surgery prior to TJA has an impact on postoperative outcomes.

Method

A systematic review was conducted according to the PRISMA 2020 guidelines. Medline and CINAHL electronic databases were searched for all relevant trials in September 2020. The primary outcome measures were rates of total hip arthroplasty dislocation, TJA revision, and peri-prosthetic and/or surgical site infections or complications at 90 days or more post-operatively.

Results

From 161 studies identified, 15 satisfied the criteria and are included in this review. A total of 3,873,630 individual patients were identified who had undergone a hip or knee TJA; of these 63,757 patients had bariatric surgery prior to a TJA.

Conclusion

This systematic review shows no clear pattern of the impact of BS on lower limb TJA. Therefore, prophylactic BS prior to lower limb TJA to induce weight loss does not significantly impact postoperative complication rates.

BACKGROUND

Osteoarthritis (OA) a degenerative joint disease characterised by breakdown of cartilage and disorganised repair resulting in the structural and functional failure of synovial joints.[1,2] It is estimated that in 2017–18, 9.3 per cent of Australians had osteoarthritis.[3] It is a leading cause of disability, limiting a patient's ability to participate in activities of daily living and impacting quality of life.

Total joint arthroplasty (TJA) is a common intervention for osteoarthritis that has not responded to conservative management. In Australia in 2019, there were 66,729 primary total knee arthroplasties (TKA) and 51,163 primary total hip arthroplasties (THA) performed.[4] Osteoarthritis was the leading indication for hip and knee arthroplasties, accounting for 97.7 per cent and 88.2 per cent of primary TKA and THA, respectively.[4]

Obesity is a strong modifiable risk factor for both the incidence and progression of lower limb osteoarthritis, particularly of the knee joint.[5] This is due to both mechanical and physiological stressors.[6] A cohort study of 1,140 patients with or at high risk of developing OA found a dose-relationship between body weight changes and self-reported pain and functional status.[6] A weight loss of >10 per cent of body weight over a 3-year period was associated with significantly lower function-related pain and improved functional status compared to the control group.[6]

The World Health Organization (WHO) defines obesity as a body mass index (BMI) of >30kg/m^2.[7] Further classification in adults of obesity class I BMI 30–34.9kg/m^2, obesity class II BMI 35–39.9kg/m^2, and obesity class III as BMI >40kg/m^2.[7]

Obesity is also associated with worse outcomes for TJA of the hip and knee.[8] Obese patients undergoing TKA have an increased risk of complications including deep prosthetic infection, superficial infections, impaired wound healing, and impaired prosthesis survival.[9] Furthermore, obesity is a reliable predictor of short- and long-term complications after THA or TKA.[10] A meta-analysis found that non-obese patients had significantly less postsurgical complications, including dislocation and infection after elective hip and knee arthroplasties.[10]

The Australian Orthopaedic National Joint Replacement Registry provides annual reports on joint arthroplasty in Australia evaluating key complications such as revision, infection, and THA dislocation rates.[4]

For primary TKA for OA, the cumulative rate of revision is 1 per cent at 1 year, 3.5 per cent at 5 years, and 9 per cent at 19 years.[4] Loosening (24.7 per cent) is the main reason for revision followed by infection (23.7 per cent) and patellofemoral pain (9.1 per cent).[4] Regarding obesity,

there is no difference in TKA revision rates between normal BMI, pre-obese or obese class 1 patients.[4] However, obese class 2 patients have an increased rate of revision in the initial 3 months as do obese class 3 over the first 6 months.[4]

Regarding primary conventional THA for OA, the cumulative rate of revision is 1.6 per cent at 1 year, 3.1 per cent at 5 years, and 10.6 per cent at 19 years.[4] This is increased at all time points in patients in obese class 1, 2, and 3.[4] The most common reasons for revision are loosening (24.2 per cent), fracture (21.1 per cent), prosthesis dislocation (20.3 per cent), and infection (18.6 per cent).[4] Dislocation is the leading cause of revision during the first 5 years post-THA.[4]

For both TKA and THA the rate of revision for infection increases with each obesity class. THA revision rate for patients in obesity class 3 is 6 times that of patients in the normal BMI range.[4]

In attempts to reduce weight and ease symptoms of OA, many patients undergo surgical weight loss or bariatric surgery (BS). The most commonly performed bariatric procedures worldwide are the non-reversible Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG), and the reversible laparoscopic adjustable gastric band (LAGB).[9] In the United States in 2019 there were 256,000 bariatric surgical procedures: 59.4 per cent were a gastric sleeve, 17.8 per cent RYGB, and 16.7 per cent revision. Band gastroplasty represented only 0.9 per cent of all procedures.[11] Weight loss surgical procedures in Australia have increased exponentially from 9,300 in 2005–6 to 22,700 in 2014–15.[12] This represents a 2.4 fold increase in interventions over a decade.[12]

While lifestyle interventions are first line for inducing weight loss, BS is the most effective treatment for clinically severe obesity, allowing for significant and maintained weight loss.[13] The resultant weight loss is associated with improved obesity-related health outcomes, decreased mortality, and an improved quality of life.[13]

The Swedish Obese Subjects (SOS) study is the longest and largest, prospective, controlled study on surgery. SOS found a maximal weight loss of 20–32 per cent was achieved at 2years post-BS and sustained at 18 per cent at 20 years compared with a non-surgical control of 0 per cent at 2 years and 1 per cent at 20 years.[14]

While BS has the primary intention of providing weight reduction, side effects include regurgitation, dysphagia, erosion of gastric band, anastomotic leak, small bowel obstruction, dumping syndrome, and micronutrient deficiencies.[13] Chronic micronutrient deficiencies are more commonly associated with RYGB and SG, which induce an element of malabsorption and can lead to long-term consequences, including nutritional anaemias, metabolic bone disease, and neurological complications.[13] Medical practitioners continue to recommend BS to patients as a treatment option prior to undergoing TJA.

Due to the impact of obesity on OA and subsequent TJA outcomes, this study aims to determine the impact BS prior to TJA has on postoperative recovery. Key outcomes to be evaluated are the

rate of THA dislocation, TJA revision, periprosthetic and/or surgical site infection, and complication rates at 90 days or more postoperatively.

METHOD

The researcher conducted a systematic review according to the PRISMA 2020 guidelines (Figure 1). The review conducted in September 2020 entailed a search of electronic records (Medline and CINAHL). The search strategy combined MeSH terms, and text words as follows:

((MH "Bariatric Surgery") OR "bariatric surgery" OR "Obesity surgery")
AND
((MH "Arthroplasty, Replacement, Knee") OR (MH "Arthroplasty, Replacement") OR (MH "Arthroplasty, Replacement, Hip") OR "total hip arthroplasty" OR "hip arthroplasty" OR "total hip replacement" OR "hip replacement" OR "total knee arthroplasty" OR "knee arthroplasty" OR "total knee replacement" OR "knee replacement")

This search yielded 161 articles. The inclusion and exclusion criteria were applied to identify the papers for review (Table 1).

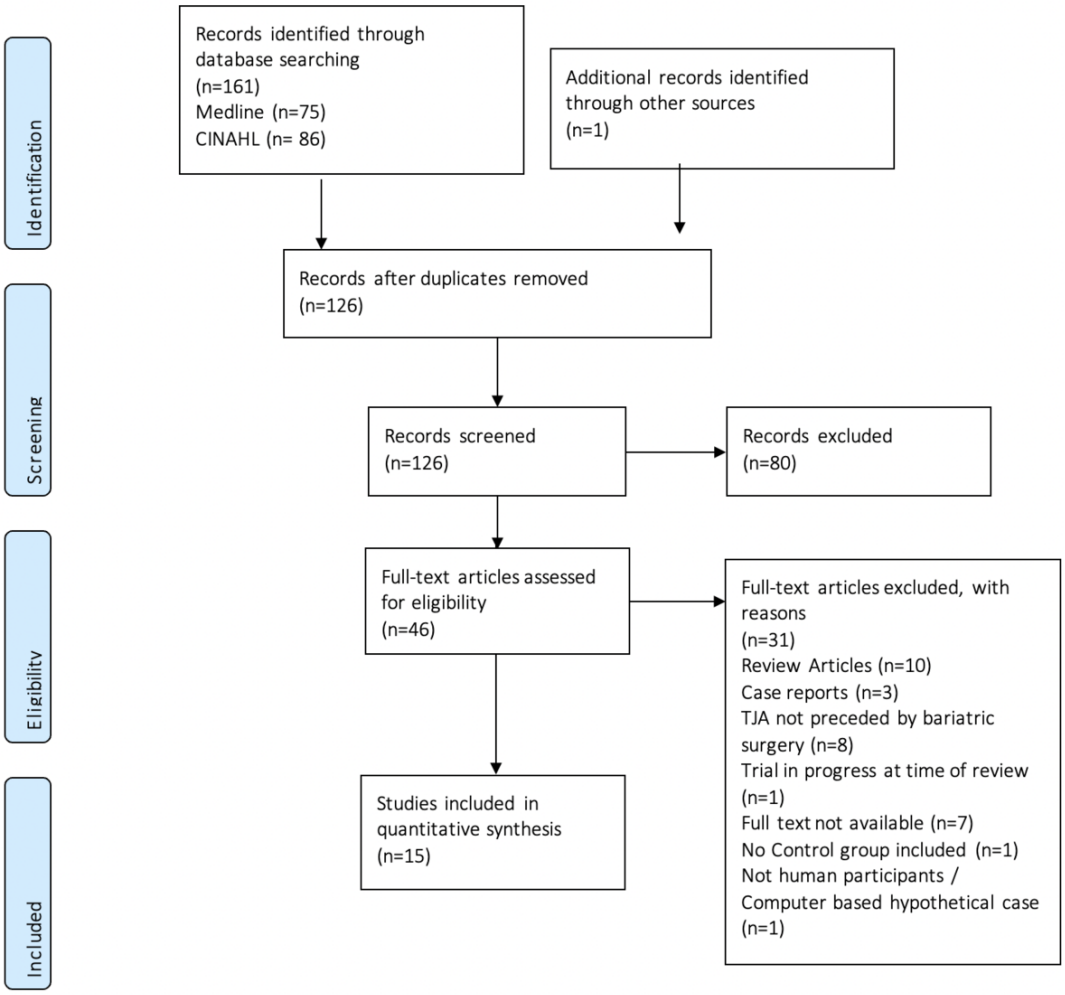
Table 1: Inclusion and exclusion criteria for systematic review

Inclusion criteria	Studies containing human subjects of any age and gender
	Studies included patients who had undergone BS prior to TJA (hip or knee)
	Studies included a control group of no BS prior to TJA
	The studies followed patients for a minimum of 90 days following TJA
	The studies presented data on complication rates and/or outcome measures for surgical complications including TJA Revision, THA Dislocation, periprosthetic or surgical site infection, and complications at 90 days or more postoperatively
Exclusion criteria	Review articles
	Case reports
	Studies that did not include a group of patients having BS prior to TJA (hip or knee)
	Studies in which all arthroplasty subjects did not undergo a to TJA (hip or knee)
	Non-English studies

Screening and Data Extraction

The researcher exported articles and removed duplicates. The lead author screened titles and abstracts of potentially relevant studies to determine their eligibility based on the criteria (Table 1). The lead author conducted critical appraisal of remaining full texts using the Critical Appraisal Skills Programme (CASP) Systematic Review Checklist appraisal tool; no studies were excluded.[15] Data were extracted focusing on the four key outcome measures: THA Dislocation rates, TJA revision rate, periprosthetic and/or surgical site infections, and complications across the subacute period at 90 days or more postoperatively.

Figure 1: PRISMA[16] flow diagram describing the selection process for relevant studies used in this systematic review



RESULTS

The database search conducted in September 2020 identified 161 articles. Hand-searching yielded one additional article, and after the researcher removed duplicates, 126 articles remained. The lead author completed a title and abstract screening using the described inclusion and exclusion criteria on all remaining studies. The lead author then completed a full-text review on all remaining papers, after which 15 papers satisfied the inclusion and exclusion criteria (Table 1) and are included in this review. Appendix A provides an overview of the key characteristics and outcomes included in each study.

A total of 3,873,630 individual patients were identified who had undergone a hip or knee TJA; of these 63,757 patients had BS prior. Two studies reviewed the same patient cohort: a total of 343,710 had a TJA, 1,478 of whom had undergone BS prior.[17,18] Appendix B outlines key demographic and patient cohort characteristics of each study.

Outcome measures assessed in this review were THA Dislocation rates, TJA revision rate, periprosthetic and/or surgical site infections, and complications across the subacute period at 90 days or more postoperatively.

Prosthetic THA Dislocation

Seven studies evaluated THA dislocation rates (Table 2). Two studies, found prior BS was associated with increased THA dislocation rates compared to obese and normal weight groups.[19, 28] This was maintained at 2 and 15 years follow-up.[19, 28] One study proposed that a residual increased thigh and hip circumference in females following BS may be associated with increased dislocation risk.[19] Two studies observed no significant difference in dislocation rates at 90 days post-operatively in and one at up to 1-year postoperative.[17,18,32] One study observed no dislocations during the study period.[26]

Table 2: THA Dislocation outcome review

Authors	Year	TJA / THA / TKA	Outcome
Hernigou et al.[19]	2017	THA	At 1-year post-THA, there was a higher rate of dislocation in patients who had previously had BS (group 3) compared to obese (group 1) and non-obese (group 2) patients. This trend was maintained until the final review at 15 years postoperative. It was noted that dislocations in the post-bariatric surgery cohort only occurred in female patients with no real reduction in hip or thigh circumference following BS. Despite decreased BMI, the risk of dislocation could be associated with increased thigh and hip circumference causing thigh impingement postoperatively.
Kulkarni et al.[21]	2011	TJA	At 18 months postoperative the risk of hip dislocation appeared to be higher in the groups who had BS and THA (group 2 and 3) compared to a typical English hip arthroplasty patient (group 1). The risk does not appear to change if BS is performed before or after the THA. This was only a trend, not statistically significant (p=1.0).
Liu et al.[17]	2018	TJA	THA dislocation was not a statistically significant ($p<0.05$) cause of readmission at 30 days, 90 days, or 1 year in the post-BS cohort.
Liu et al.[18]	2020	TJA	No statistically significant difference in hip or knee dislocation rates between patients who had BS prior to TJA (group 1) and obese (group 2) or non-obese (group) patient groups at 90 days post-TJA.
Mclawhorn et al.[24]	2018	TJA	BS did not reduce the risk of dislocation following THA.
Nearing et al.[26]	2017	TJA	No dislocations observed in either group over the study period.
Nickel et al.[28]	2018	THA	BS prior to TJA has an increased rate of dislocation at 90 days and 2 years compared to obese and normal weight groups.

BS=bariatric surgery, BMI=body mass index, OA=osteoarthritis, TJA=total joint arthroplasty, THA=total hip arthroplasty, TKA=total knee arthroplasty

Revision

Eleven studies examined TJA revision rates with seven studies associating prior BS with an increased TJA Revision rate (Table 3).

Table 3: TJA Revision outcome review

Authors	Year	TJA / THA / TKA	Outcome
Inacio et al.[20]	2014	TJA	Patients who had BS more than 2 years prior to the TJA had a higher all cause revision density than those who had BS within 2 years of TJA and those without BS.
Kulkarni et al.[21]	2011	TJA	No statistical difference in revision rate between groups (p=1.0)
Lee et al.[22]	2018	TJA	Post-BS patients undergoing a primary THA had an increased adjusted hazard ratio of revision risk due to periprosthetic joint infection at 0.5 and 5 years for the post-BS primary THA group. No other statistically significant differences noted. Patients undergoing a primary TKA after BS were at an increased risk of revision (any reason) at 1, 2, and 5 years postoperatively.
Liu et al.[17]	2018	TJA	BS prior to TJA did not show a statistically significant difference in readmission for TJA revision at 30 days, 90 days, and 1 year.
Martin et al.[23]	2015	TKA	Increased risk for revision in the BS group when compared to the low BMI group. No difference noted in the BS vs high BMI group.
Mclawhorn et al.[24]	2018	TJA	The risk of revision arthroplasty was not statistically significantly different for groups receiving preoperative BS.
Meller et al.[25]	2019	TKA	Increased hazard ratio for revision TKA in patients who had previously undergone a band gastroplasty and unknown bariatric procedures, respectively. However, these increased hazard ratios of revision rates, while statistically significant, represent a small population of the 2,701,427 patients who had TKA during the study period.
Nearing et al.[26]	2017	TJA	No statically significant difference in revision if BS occurs before or after TJA
Nickel et al.[27]	2016	TKA	Post-BS patients have higher TKA revision rates when compared to obese (BMI>40) or normal weight (BMI <25) groups at 90 days and 2-year follow up.
Nickel et al.[28]	2018	THA	At 90 days post-THA the BS and obese group had increased incidence of revision compared to the normal weight group. At 2 years the BS group had significantly higher incidence of revision, nearly twice that of the two other groups.
Severson et al.[29]	2012	TKA	Group 3 with BS >2 years prior to TKA appeared to have the highest rate of revision. This study is underpowered and therefore unable to identify a reliable difference in revision rates.

BS=bariatric surgery, BMI=body mass index, OA=osteoarthritis, TJA=total joint arthroplasty, THA=total hip arthroplasty, TKA=total knee arthroplasty

Of these, two studies evaluated whether the time interval between BS and TJA affected revision rate.[20,29] One study reported an increased all cause revision density in patients who had BS >2 years prior to the TJA compared to those without BS.[20] Another study observed the highest rate of revision in those who had BS >2 years prior to TKA, however, this study is underpowered and therefore unable to identify a reliable difference in revision rates.[29] Regarding type of BS performed, one study reported increased TKA revision rates in patients with a history of band gastroplasty and "unknown bariatric procedure".[24]

Three studies assessed the impact of BS on revision when compared to patients with a similar preoperative BMI.[23,24,28] In one study, post-BS patients had increased TKA revision rates compared to obese (BMI>40) or normal weight (BMI <25) groups at up to 2 years follow-up.[27] Another found for THA, post-BS and obese patients had an increased revision rate at 90 days compared to the normal weight group.[28] By 2 years the post-BS group had a significantly higher incidence of revision, nearly twice that of the two other groups.[26] One study found prior BS was associated with an increased risk for TKA revision when compared to those with an equivalent BMI at time of TKA, however, not the pre-BS BMI comparison group.[23] Four studies found no statistically significant change in TJA revision rates associated with prior BS.[17,21,24,26]

Periprosthetic and/or Surgical Site Infection

Eleven studies evaluated periprosthetic and/or surgical site infection rates (Table 4). Five studies observed no statistical difference in periprosthetic or surgical site infection rates.[17,18,20,23,30]

Four studies found increased periprosthetic and/or surgical site infection rates associated with BS.[18,25,27,28] One study compared bariatric procedures, noting an increased risk of prosthetic joint infections in patients who had undergone a band gastroplasty and "unknown bariatric procedures".[25] Regarding comparisons to BMI classes, BS was associated with significantly increased odds ratio for prosthetic joint infection at 90 days compared to normal weight patients post-TKA and both obese and normal weight patients at 2 years post-TKA.[27] For THA, one study found the rate of periprosthetic infection and wound complication were similarly increased at 90-days and 2 years post THA in both obese and post-BS patients compared to the normal BMI group.[28]

Two studies reported decreased infection rates in those who had BS prior to TJA.[21,31] BS prior to TJA appeared to have a wound infection rate 3.5 times lower than obese patients who had BS after TJA.[21] One study found prior BS was associated with significantly decreased postoperative infection rates compared to morbidly obese patients, however, no difference when compared to non-obese patients.[31]

Table 4: Periprosthetic and/or surgical site infection outcome review

Authors	Year	TJA / THA / TKA	Outcome
Inacio et al.[20]	2014	TJA	There was incidence of deep infection was similar between all groups.
Kulkarni et al.[21]	2011	TJA	Within the two obese groups who underwent BS and TJA, those who had BS prior to TJA (group 3) appeared to have a wound infection rate 3.5 times lower.
Lee et al.[22]	2018	TJA	BS prior to THA was positively correlated with increased risk for postoperative infections with a trend towards a greater revision risk for PJI at 5 years for BS patients. There was no statistically significant difference in the hazard ratio for periprosthetic joint infection requiring revision post-TKA in BS patients.
Liu et al.[17]	2018	TJA	There was no statistically significant difference in readmission for infection or inflammation reaction due to internal joint prosthesis in the BS group (group 1). At 90 days the BS group (group 1) had a significantly higher incidence of readmission for debridement of wound infection compared with obese or normal weight controls (group 2 and 3).
Liu et al.[18]	2020	TJA	No statistically significant difference in infection rates between patients who had BS prior to TJA (group 1) and obese (group 2) or non-obese (group) patient groups at 90 days post-TJA.
Martin et al.[23]	2015	TKA	There were no statistically significant differences in the rates of complications or PJI between groups.
Meller et al.[25]	2019	TKA	There is an increased hazard ratio for prosthetic joint infection in patients who had previously undergone a bariatric procedure, especially band gastroplasty and "unknown bariatric procedures".
Nickel et al.[27]	2016	TKA	At 90 days post TKA the BS group had a significantly increased odds ratio of prosthetic joint infection compared to normal weight patients (group 3). At 2 years post-TKA the BS group had an increased odd ratio for prosthetic infection compared to both the obese (group 2) and normal weight (group 3) patients.
Nickel et al.[28]	2018	THA	At 90 days the rate of periprosthetic infection and wound complication were similarly increased in patients who were obese (group 2) and had BS prior to THA (group 1) when compared to the normal BMI group (group 3). This trend was continued at 2 years.
Wang et al.[30]	2019	TJA	No significant difference in infection rate post-TJA when morbid obese and post-BS patients matched by formula A or B.
Werner et al.[31]	2015	TKA	Significantly decreased postoperative infection rate in those who had BS (group 3) compared to morbidly obese patients (group 2). No difference in post-operative infection rates between non-obese (group 1) and post-BS (group 3) patient groups.

BS=bariatric surgery, BMI=body mass index, OA=osteoarthritis, TJA=total joint arthroplasty, THA=total hip arthroplasty, TKA=total knee arthroplasty

Complications at 90 days or more Postoperatively

Eight studies reviewed complication rate at 90 days of more postoperatively (Table 5).

Table 5: Complications at 90 days or more post-operatively

Authors	Year	TJA / THA / TKA	Outcome
Inacio et al.[20]	2014	TJA	Readmissions within 90 days of TJA was highest in patients with BS >2 years prior to TJA (group 1). Patients who had BS within 2 years of TJA had the lowest 90-day readmission rates.
Liu et al.[17]	2018	TJA	When comparing nonelective readmission rates, there was no significant difference between patients who had BS prior to TJA (group 1) and those who were obese (group 2) at 90 days or 1 year.
Liu et al.[18]	2020	TJA	At 90-days postoperatively, patients who had BS prior to TJA (group 1) had more 90-day complications than obese patients undergoing TJA (group 2).
Martin et al.[23]	2015	TKA	No statistically significant difference in overall complication rates between groups. Survival free of re-operation (with 95% CI) was worse in the BS group at both 1 year and 5 years when compared to low and high BMI patient groups.
Mclawhorn et al.[24]	2018	TJA	In morbidly obese patients, when BS is performed prior to TJA, it is associated with reduced 90-day postoperative complications for TKA. No difference was found in 90-day complication rates in the THA patient groups.
Meller et al.[25]	2019	TKA	At 90 days post-TKA patients who had undergone BS were at an increased risk of complications compared with the entire TKA population.
Severson et al.[29]	2012	TKA	No statistically significant difference in 90-day complication rates observed between patients regardless of their temporal relationship between BS and TKA.
Werner et al.[31]	2015	TKA	Morbidly obese patients who had undergone BS prior to TKA had significantly increased rates of major and minor postoperative complications at 90 days when compared to non-obese patients. Note: This includes medical and surgical complications.

BS=bariatric surgery, BMI=body mass index, OA=osteoarthritis, TJA=total joint arthroplasty, THA=total hip arthroplasty, TKA=total knee arthroplasty

Three studies found no statistical difference in outcomes at 90 days or more post-TJA.[17,23,29] One study found mix results with a decreased 90-day complications for post-BS patients undergoing TKA but not for THA.[24]

Three studies found increased rates of complication at 90 days or more postoperatively.[18,25,31] One study observed that prior BS was associated with increased rates of complications at 90 days post-TJA compared to obese patients.[18] Another study found BS prior to TKA was associated with significantly increased rates of major and minor postoperative complications at 90 days when compared to non-obese patients.[31] However, this study did not separate medical and surgical complications. A separate study found patients who had BS prior to TKA were at an increased risk of complications at compared with the entire TKA population.[25] Another study found that

readmission rates within 90 days of TJA was highest in those who BS >2 year prior to TJA and lowest in those having TJA within 2 years of bariatric surgery.[20]

DISCUSSION

The purpose of this literature review was to assess the impact of prior BS on patients undergoing TJA. Of the key complications reviewed—namely, THA dislocation, TJA revision, peri-prosthetic and/or surgical site infection, and complications at 90 or more days post-operatively— there were no consistent results across the studies included.

Studies that reviewed the association between BS and THA dislocation mainly reported no difference. Of the three studies that noted an increased in dislocation rates, one associated it with an increased thigh and hip circumference after weight loss causing hip impingement.[19,21,28] This is a possible area for further research.

It appears prior BS may be associated with increased TJA revision rates, however, there is no consistent evidence across the 11 studies identified. Six associated prior BS with increased risk for subsequent TJA revision and four found no significant difference.[17,20–22,24–29] One identified an increased revision risk when compared to a low BMI group but not a high BMI.[22]

There was conflicting results regarding peri-prosthetic and/or surgical site infection rates in post-BS patients. Two studies found prior BS was associated with decreased postoperative infections when compared to obese patients.[21,31] However, four studies reported increased periprosthetic and/or surgical site infections in post-BS patients.[17,22,25,27,28]

In regard to overall complications at 90 days or more postoperatively there was no consistent data. Four of the eight studies found BS to be associated with increased complications.[18,20,25,31] One study found no significant difference in complication rates, however, a worse survival free of re-operation at 1 and 5 years.[23] One study found reduced complications at 90 days for patients undergoing TKA but not THA.[24]

These findings are consistent with three previous reviews on the relationship between BS and TJA outcomes. A 2018 literature review found inconclusive outcomes regarding the benefits of BS prior to TJA, recommending prospective studies for further research.[33] A meta-analysis of 38,728 patients over nine studies found BS prior to TJA was associated with decreased short-term medical complications and TKA peri-prosthetic infections, however, it did not reduce the risks of superficial wound infection, long-term dislocation, peri-prosthetic infection and revision.[34] Hence, this study concluded that although BS prior to TJA was associated with moderately improved short-term outcomes, it did not improve the risks for long-term outcomes.[34] A different literature review of 13 studies found mixed results regarding BS prior to TJA.[8] Nine studies associated BS prior to TJA with decreased major and minor postoperative complications, risk of re-operation, and 90-day readmission.[8] However, two studies correlated BS with increased rates of stiffness, infection, and revision at 90 days post TJA.[8] Of two meta-analyses reviewed, one found no statistically significant differences in wound infections, revisions, or mortality rate,

while another reported reduced medical complication and length of stay when BS is performed prior to TJA.[8] Therefore, the findings of this study are consistent with previous literature, which observes no clear evidence of overall outcomes for TJA after BS.

Limitations

There were many limitations of the studies included in this review. All data were retrospectively acquired. Ideally, a prospectively controlled cohort or randomised control trial could improve the accuracy of data collected.

In most of the studies included in this review, there is a strong reliance on health report coding to capture accurate patient information. Most studies utilised the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). This is heavily reliant on accurate capturing of patient records through medical coding and documentation.

In many studies it is unclear what BS was performed prior to the TJA. Only one study included in this review compared different types of BS primarily classifying patients into band gastroplasty, sleeve gastrectomy, gastric bypass, and "procedure not specified" groups.[25] This classification enabled comparison between the range of surgical interventions on outcomes to be assessed.

As a result of studies being based on retrospective audit data, there was a lack of information regarding the indication for BS or surgery each patient received. The indication for each BS intervention, patients' associated co-morbidities, their suitability for surgery, and the timeframe of osteoarthritis was unknown. There was marked variability in patient cohorts included. All these variables make the association between BS and total joint arthroplasty outcomes difficult. Overall, many studies did not take into account patient co-morbidities or age, nor did they ensure a wide sample of the general population was included. Due to this fact, results are nuanced by the population selected. In many studies patients' BMI was unknown, hence a patient may have had BS without inducing significant weight loss, which complicates data interpretation. Variability in patient cohorts and outcomes made direct comparisons across studies difficult.

CONCLUSION

While the association between obesity, arthritis, and poor total joint arthroplasty outcomes are recognised, overall, this literature review shows no clear pattern of the impact of BS on lower limb total joint arthroplasty. Therefore, prophylactic BS prior to lower limb TJA to induce weight loss does not significantly improve postoperative complication rates. This is consistent with previous studies and reviews. A cohort matched observational study would be beneficial in further determining the utility of BS in relation to total joint arthroplasty outcomes.

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PEER REVIEW

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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ETHICS COMMITTEE APPROVAL

The report was prepared in accordance with the NHMRC Guidelines for the Conduct of Ethical Research.[1] All data were acquired from information sources that are freely and publicly available, and did not involve research on human subjects, nor the collection of data via questionnaires or other research tools. Ethical review by a human ethics research committee was therefore not required.

Appendix A: Overview of studies included in this systematic review

Authors	Year	TJA/ THA/ TKA	Study Type	Data Set	Overall Number Of Patients Undergoing TJA / Included in Trial	Patients Undergoing Bariatric Surgery Before TJA	Outcomes Reviewed in This Study
Hernigou et al.[19]	2017	THA	Case control study	Single centre	670	85	THA Dislocation
Inacio et al.[20]	2014	TJA	Retrospective cohort study	Integrated healthcare system's Total Joint Replacement Registry (TJRR)	11,203	171	TJA Revision Periprosthetic and/or surgical site infection
Kulkarni et al.[21]	2011	TJA	Retrospective cohort study	NHS–Hospital Episode Statistics (HES) database	496,205[a]	90	THA Dislocation Periprosthetic and/or surgical site infection
Lee et al.[22]	2018	TJA	Retrospective cohort study	Medicare 5% part B data from 1999 to 2012	134,504	105	TJA Revision Periprosthetic and/or surgical site infection
Liu et al.[17]	2018	TJA	Retrospective cohort study	New York State-wide Planning and Research Cooperative System database	343,710	1,478	THA Dislocation TJA Revision Periprosthetic and/or surgical site infection
Liu et al.[18]	2020	TJA	Retrospective cohort study	New York State- wide Planning and Research Cooperative System database	343,710	1,478	Complications at 90 days or more postoperatively
Martin et al.[23]	2015	TKA	Retrospective matched cohort study	Mayo Clinic Joint Registry	364	91	TJA Revision Periprosthetic and/or surgical site infection Complications at 90 days or more postoperatively
Mclawhorn et al.[24]	2018	TJA	Retrospective cohort study	New York Statewide database	6,856	3,428	THA Dislocation TJA Revision Periprosthetic and/or surgical site infection Complications at 90 days or more postoperatively Type of BS performed
Meller et al.[25]	2019	TKA	Retrospective cohort study	USA Medicare hospital claims data.	2,701,427	25,852	TJA Revision Periprosthetic and/or surgical site infection Complications at 90 days or more postoperatively
Nearing et al.[26]	2017	TJA	Retrospective cohort study	Integrated multispecialty group medical centre serving 19 counties over a 3-state region	102	66	THA Dislocation TJA Revision Periprosthetic and/or surgical site infection Complications at 90 days or more postoperatively
Nickel et al.[27]	2016	TKA	Retrospective cohort study	Medicare patient data from January 1, 2005 to December	39,014	5,914	THA Dislocation TJA Revision Periprosthetic and/or surgical site infection

				31, 2012 using the PearlDiver Technologies database			Complications at 90 days or more postoperatively
Nickel et al.[28]	2018	THA	Retrospective cohort study	Medicare patient data from January 1, 2005 to December 31, 2012 using the PearlDiver Technologies database	12,160	1,545	THA Dislocation TJA Revision Periprosthetic and/or surgical site infection Complications at 90 days or more postoperatively
Severson et al.[29]	2012	TKA	Retrospective cohort study	Institutional registry	125	86	TJA Revision
Wang et al.[30]	2019	TJA	Retrospective cohort study	Nationwide Inpatient Sample (NIS), a database released by the Healthcare Cost and Utilization Project	49,254	24,627	Complications at 90 days or more postoperatively
Werner et al.[31]	2015	TKA	Retrospective cohort study	PearlDiver Patient Records Database	78,036	219	Complications at 90 days or more postoperatively

TJA=total joint arthroplasty, THA=total hip arthroplasty, TKA=total knee arthroplasty.
[a] – 23,092 hip resurfacing arthroplasties also included in total population however not included in post-BS cohort.

Appendix 2: Populations demographics, post-BS cohort characteristics, and patient grouping of each study in review

Authors	Year	TJA/ THA/ TKA	Overall Number of Patients Undergoing TJA / Included In Trial	Patients Undergoing BS Before TJA	Post-BS Cohort Characteristics	Patient Groups
Hernigou et al.[19]	2017	THA	670	85	1. *BS procedure performed*—Data identifying BS or procedure undergone by each patient not identified. 2. *Interval BS to TJA* – not noted 3. BMI at time of TJA – <30Kg/m^2 (mean 27.6Kg/m^2) 1. *Inter-group matching of patient demographics* – No matching between groups. Study demographic characteristics further outlined in report. 4. *Follow-up period* – minimum 5 years 5. *TJA details* – all THA Posterolateral approach under general anaesthetic	**Group 1**- Obese (BMI>30 Kg/m^2) on day of surgery (n=215) **Group 2** – Nonobese (BMI<30 Kg/m^2) on day of surgery (n=215) **Group 3** – Previously obese with history of BS and BMI <30 Kg/m^2 on day of surgery (n=85) **Group 4** – Obese (BMI >30 Kg/m^2) on day of surgery receiving dual mobility or constrained liner implants (n=155)
Inacio et al.[20]	2014	TJA	11,203	171	2. *BS procedure performed* – ICD-9 procedure codes used to identify prior BS cohort. Data on procedure undergone by each patient not identified. 3. *Interval bariatric surgery to TJA* o Group 1 – BS >2 years prior to TJA (n= 69) o Group 2 – BS within 2 years of TJA (n=102) 4. *BMI at time of TJA* – o Group 1 – mean 34.6 Kg/m^2 o Group 2 – mean 32.4 Kg/m^2 5. *Inter-group matching of patient demographics* – No matching between groups. Study demographic characteristics further outlined in report. 6. *Follow-up period* – o Group 1 – mean 320 days o Group 2 – mean 691 days o Group 3 – mean 1076 days 7. *TJA details* – Not noted	**Group 1** – BS >2 years prior to TJA (n= 69) **Group 2** – BS within 2 years of TJA (n=102) **Group 3** – TJA with no prior BS, however, would be candidate due to criteria - BMI ≥40 Kg/m^2 or - BMI ≥ 35 Kg/m^2 and one other co-morbidity (ie, Diabetes, hypertension, livery disease, and chronic lung disease) in addition to osteoarthritis.

Kulkarni et al.[21]	2011	TJA	51,9297	90	1. *BS procedure performed* – ICD-10 procedure codes used to identify prior BS cohort. Data on procedure undergone by each patient not identified. 2. *Interval bariatric surgery to TJA* – minimum 6 months 3. *BMI at time of TJA* – Not noted 4. *Inter-group matching of patient demographics* - No matching between groups. Study demographic characteristics further outlined in report. 5. *Follow-up period* – 18 months 6. TJA details – Not noted	**Group 1** – All TJA population (n=519,297) **Group 2** – TJR followed by BS (n=53) **Group 3** – BS >6 months prior to TJA (n=90)
Lee et al.[22]	2018	TJA	134,504	105	1. *BS procedure performed* – ICD-9 procedure codes used to identify prior bariatric surgery cohort. Details in Appendix A of report. Data on procedure undergone by each patient not identified. 2. *Interval BS to TJA* – within 24 months 3. *BMI at time of TJA* – Not noted 4. *Inter-group matching of patient demographics* - Statistical analysis adjusted for age, gender, socioeconomic status, race, Charlson comorbidity score and metabolic bone conditions. 5. *Follow-up period* – 5 years 6. *TJA details* – Not noted	**Primary THA cohort:** – Total (n=47, 89) – BS within prior 24months (n=35) **Primary TKA cohort:** – Total (n=86,609) – BS within prior 24 months (n=70)
Liu et al.[17]	2018	TJA	343,710	1,478	1. *BS procedure performed* – ICD-9 procedure codes used to identify prior BS cohort. Data on procedure undergone by each patient not identified. 2. *Interval BS to TJA* – within 2 years. 3. *BMI at time of TJA* – Not noted 4. *Inter-group matching of patient demographics* - No matching between groups. Study demographic characteristics further outlined in report. 5. *Follow-up period* – 1 year 6. *TJA details* – Not noted	**Group 1** - Obese patients who underwent BS within 2 years of TJA (n=1,478) **Group 2** - Patient diagnosed with obesity do did not undergo BS withing2 years prior of TJA (n=60,259) **Group 3** - Patients who were not obese and did not undergo BS (n=281,973)
Liu et al.[18]	2020	TJA	343,710	1,478	1. *BS procedure performed* – ICD-9 procedure codes used to identify prior BS cohort. Data on procedure undergone by each patient not identified. 2. *Interval BS to TJA* – within 2 years. 3. *BMI at time of TJA* – Not noted	**Group 1** - Obese patients who underwent BS within 2 years of TJA (n=1,478) **Group 2** - Patient diagnosed with obesity do did not undergo BS within 2 years of TJA (n=60,259)

					4. *Inter-group matching of patient demographics* - No matching between groups. Study demographic characteristics further outlined in report. 5. *Follow-up period* – 1 year 6. *TJA details* – Not noted	**Group 3** - Patients who were not obese and did not undergo BS (n=281,973)
Martin et al.[23]	2015	TKA	364	91	1. *BS procedure performed* - The Mayo Clinic Joint Registry used to identify BS prior to TJA cohort. Data on procedure undergone by each patient not identified. 2. *Interval BS to TJA* – Mean time from Bariatric surgery to TKA – 46.5 months 3. *BMI at time of TJA* – mean 37.2 Kg/m^2 4. *Inter-group matching of patient demographics* – Matched for age within 4 years, gender, BMI within 1 Kg/m^2, date of TKA within 4 years. 5. *Follow-up period* – o Bariatric group – mean 3.9 years o High & low BMI groups – 4.1 years 6. *TJA details* - Not noted	**Group 1** - 1:1 Matched using pre-BS BMI (mean BMI 51.2Kg/m^2) (n=182) - BS prior to TKA (n=91) - Pre-BS (high BMI) matched TKA (n=91) **Group 2** - 2:1 matched using the BMI achieved at TKA after undergoing BS (mean BMI 37.2 Kg/m^2) (n=273) - BS prior to TKA (n=91) - Post-BS (low BMI) matched TKA (n=182)
Mclawhorn et al.[24]	2018	TJA	6,856	3,428	1. *BS procedure performed* – ICD-9 and CPT procedure codes used to identify prior BS cohort. Detailed in appendix of report. Data on procedure undergone by each patient not identified. 2. *Interval BS to TJA* – Not noted 3. *BMI at time of TJA* – Not noted 4. *Inter-group matching of patient demographics* – propensity score utilised for matching between groups. Baseline characteristics used in estimating propensity score include – age, gender, Elixhauser co-morbidities, insurance status, laterality, year of operation and region. 5. *Follow-up period* – 90 days 6. *TJA details* – Not noted	**Group 1**– BMI of >40 $Kg/m^2$with no BS prior to THA (n= 792) **Group 2** – BS prior to THA (n=792) **Group 3** – BMI of >40 Kg/m^2 with no BS prior to TKA (n=2,636) **Group 4** – BS prior to TKA (n=2,636)
Meller et al.[25]	2019	TKA	2,701,427	25,852	1. *BS procedure performed* – CPT and ICD-9 procedure codes used to identify prior BS cohort. Data on procedure undergone by each patient not identified. 2. *Interval bariatric surgery to TJA* – not noted 3. *BMI at time of TJA* – Not noted	**Group 1** – Post-BS TKA compared with the entire TKA cohort - Entire TKA cohort (n=2,701,427) - Post-BS prior to TKA cohort (n=25,852) **Group 2** – Post-BS TKA compared with a similar cohort with a BMI of greater than 40

					4. *Inter-group matching of patient demographics* – No matching between groups. Study demographic characteristics further outlined in report. 5. *Follow-up period* – 90 days 6. *TJA details* – Not noted	Kg/m^2 who submitted to a TKA without previous BS. - Post-BS prior to TKA cohort (n=25,852) - BMI >40 Kg/m^2 without BS prior to TKA (n=not noted)
Nearing et al.[26]	2017	TJA	102	66	1. *BS procedure perfo*rmed – Medical records review used to identify prior BS cohort. 90% of study population received Roux-en-Y gastric bypass and remaining 10% underwent laparoscopic sleeve gastrectomy. Data on procedure undergone by each patient not identified. 2. *Interval BS to TJA* – Mean 4.9 (+/- 3.2) years before TJA 3. *BMI at time of TJA* – o Group 1 – mean BMI 43.7 (+/- 5.7) Kg/m^2 o Group 2 – mean BMI 37.6 (+/- 7.4) Kg/m^2 4. *Inter-group matching of patient demographics* – No matching between groups. Study demographic characteristics further outlined in report. 5. *Follow-up period* – o Group 1 – mean 3.2 (+/-2.8) years o Group 2 – mean 9.2 (+/- 3.9) years 6. *TJA details* – Not noted	**Group 1** – BS prior to TJA (n=66) **Group 2** – BS after TJA (n=36)
Nickel et al.[27]	2016	TKA	39,014	5,914	1. *BS procedure performed* – ICD-9 procedure codes used to identify prior BS cohort. Data on procedure undergone by each patient not identified. 2. *Interval BS to TJA* – Not noted 3. *BMI at time of TJA* – Not noted 4. *Inter-group matching of patient demographics* – No matching between groups. Study demographic characteristics further outlined in report. 5. *Follow-up period* – minimum 2 years 6. *TJA details* – Indication for TKA: Osteoarthritis	**Group 1** – BS prior to TKA (n=5,914) **Group 2** – Bariatric control group: BMI>40 Kg/m^2 at time of TKA (n=26,616) **Group 3** – Normal weight control group: BMI <25 Kg/m^2 at time of TKA (n=6,480)
Nickel et al.[28]	2018	THA	12,160	1,545	1. *BS procedure performed* - ICD-9 procedure codes used to identify prior BS cohort. Data on procedure undergone by each patient not identified. 2. *Interval BS to TJA* – Not noted 3. *BMI at time of TJA* – Mean 36.5 Kg/m^2	**Group 1** – BS prior to THA (mean BMI 36.5 Kg/m^2) (n=1,545) **Group 2**– Bariatric patient control (BMI >40 Kg/m^2) (n=6,918) all patients undergoing THA for OA by ICD-9 diagnosis codes

					4. *Inter-group matching of patient demographics* – No matching between groups. Study demographic characteristics further outlined in report. 5. *Follow-up period* – 2 years 6. *TJA details* – Indication for THA: Osteoarthritis	
Severson et al.[29]	2012	TKA	125	86	1. BS procedure performed – Institutional database search used to identify prior BS (gastric bypass or gastric banding) cohort. Data on procedure undergone by each patient not identified. 2. *Interval BS to TJA* – o Group 2 - underwent TKA less than or equal to 2 years after BS o Group 3 - underwent TKA greater than 2 year after BS 3. *BMI at time of TJA* – o Group 2 – mean 37.9 Kg/m^2 o Group 3 – mean 38.5 Kg/m^2 7. *Inter-group matching of patient demographics* – No matching between groups. Study demographic characteristics further outlined in report. 4. *Follow-up period* – 22months -14 years 5. *TJA details* – Not noted	**Group 1** – TKA before Bariatric surgery (n=39) **Group 2** – Underwent TKA less than or equal to 2 years after BS (n=25) **Group 3** – Underwent TKA greater than 2 year after BS (n=61)
Wang et al.[30]	2019	TJA	49,254	24,627	1. *BS procedure performed* – ICD-9 procedure codes used to identify obese and BS cohort. Data on procedure undergone by each patient not identified. 2. *Interval BS to TJA* – Not noted 3. *BMI at time of TJA* – Not noted 8. *Inter-group matching of patient demographics* - Two matching formulae utilised involving baseline patient characteristics used to calculate propensity score. 1:1 patient matching base on formulae. Study demographic characteristics further outlined in report. 4. *Follow-up period* – Not noted 5. *TJA details* – Not noted	**THA:** **Formula A** – 2,540 pairs of patients with morbid obesity and patients with BS **Formula B** – 2,515 pairs of patients with morbid obesity and patients with BS **TKA:** **Formula A** – 9,803 pairs of patients with morbid obesity and patients with BS **Formula B** – 9,803 pairs of patients with morbid obesity and patients with BS
Werner et al.[31]	2015	TKA	78,036	219	1. *BS procedure performed* – CPT and ICD-9 procedure codes used to identify prior BS (laparoscopic banding or gastric bypass) cohort. Data on procedure undergone by each patient not identified.	**Group 1** – Morbidly obese at time of TKA (n=11,294) **Group 2** – Non-obese at time of TKA (n=66,523) **Group 3** – TKA after BS (n=219)

					2. *Interval BS to TJA* – Total post-bariatric surgery patient: (n=219) o TKA within 1 year of bariatric surgery n=70 o TKA between 1-2 years of bariatric surgery n=59 o TKA more than 2 years after bariatric surgery n =90 3. *BMI at time of TJA* – Not noted. 9. *Inter-group matching of patient demographics* – No matching between groups. Study demographic characteristics further outlined in report. 4. *Follow-up period* – 90 days 5. *TJA details* – Not noted	
BS=bariatric surgery, OA=osteoarthritis, TJA=total joint arthroplasty, THA=total hip arthroplasty, TKA=total knee arthroplasty, CPT=Current procedure terminology codes, ICD-9=International Classification of Diseases-9, ICD-10=International Classification of Diseases-10						