



## Review Article

## The incidence of fractures following bariatric surgery: A systematic review

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## ABSTRACT

**Introduction:** The effects of bariatric surgery on improvement of the metabolic syndrome is well-described, but its effect on intrinsic bone fragility and fracture propagation is unclear. Therefore, the aims of this systematic review of the literature were to examine (1) the incidence of fracture following bariatric surgery, (2) the association of fracture with the specific bariatric surgical procedure, and (3) site-specific types of fractures associated with bariatric surgery.

**Methods:** A comprehensive literature search was conducted through Medline, Embase, Scopus, Web of Science, Dare, Cochrane library, and HTA database. The search terms used were gastric bypass, sleeve gastrectomy and fracture.

**Results:** Eight studies were included ( $n = 42,567$  patients). This included no randomized controlled trials. The average patient age was 43.3 years and 24.9% of patients were male. The average follow-up time was 3.7 years. 1960 patients had at least one fracture, and the total number of fractures encountered was 2326. Overall, 4.6% of patients who underwent bariatric surgery suffered from a fracture post-operatively. The operation associated with the greatest risk of fractures post-operatively was following a biliopancreatic diversion (10.66%), followed by restrictive procedures such as adjustable gastric band and sleeve gastrectomy (5.71%), with the Roux-en-Y gastric bypass having the lowest risk (2.66%). Of the fractures encountered, 1458 (63.08%) were of the lower extremity and pelvis and 763 (33.01%) were of the upper extremity. Only 90 (3.89%) axial skeleton fractures were reported.

**Conclusions:** The overall risk of sustaining a fracture of any type after undergoing bariatric surgery is approximately 5 percent after an average follow up of 3.7 years. The greatest risk of fractures is associated with the biliopancreatic diversion surgery, with the Roux-en-Y gastric bypass being the most favorable. Fractures following bariatric surgeries tend to occur mostly in the lower extremity and pelvis.

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## 1. Introduction

There are well-established health risks and concerning global health challenges regarding the rising prevalence of obesity worldwide. It is estimated that the prevalence of being overweight and obese combined rose by 27.5% and 47.1% for adults and children, respectively, between 1980 and 2013 [1]. This represents more than 2 billion individuals globally. Lim et al. (2012) reported that 3.4 million deaths and 3.8% of disability-adjusted life-years in 2010 were caused by being overweight and obesity alone [2].

For many years it was believed that bone health was one of the few aspects of health that was not negatively affected by obesity. However, new compelling evidence has challenged this belief. In fact, there are suggestions that obesity is associated with deficiencies in calcium and vitamin D [3–5], ultimately adversely influencing bone metabolism and bone mineral density (BMD) [4,6]. Despite the widespread belief that obesity provides protection against osteoporosis [7], individuals with severe obesity are believed to be at increased risk of fracture compared with less-obese and non-obese controls [8].

As bariatric surgery is effective in inducing weight loss, improving glycemic control and reducing cardiovascular risk factors [9]; it is being increasingly used in several countries [10]. Rousseau et al. (2016) have recently shown that patients with severe obesity undergoing bariatric surgery are in fact at high risk of

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suffering a fracture post-operatively [8]. This apparently only held true following biliopancreatic diversion (BPD) surgery, leaving risk of fracture following Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy to be clarified. This study also features the change in fracture pattern after bariatric surgery to a pattern typical seen in individuals with osteoporosis rather than a pattern associated with obesity. More recently, Yu et al. (2017) demonstrated in a large-scale study that non-vertebral fracture risk associated with RYGB manifested >2 years after surgery and increased in subsequent years, with the highest risk in the fifth year, in comparison to the adjustable gastric band (AGB) surgery [11].

Osteoporotic fractures in themselves represent a growing public health challenge, with a projected increasing incidence with the aging population [12]. The long-term mortality risk associated with all major types of low-trauma fractures is associated with increased mortality risk for 5–10 years [13]. These fractures also increase the risk of subsequent fracture [14].

It remains unclear what drives the site-specific changes in fracture pattern following bariatric surgery. However, should this association be surgery-dependent, it would be imperative to emphasize the importance of this association.

Therefore, the aims of this systematic review of the literature were to examine (1) the incidence of fracture following different types of bariatric surgeries, (2) the association of fracture with the specific bariatric surgical procedure, and (3) site-specific types of fractures associated with bariatric surgery.

## 2. Methods

### 2.1. Literature search

The findings were reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [15], and the systematic review was registered in a Research Registry (UIN: reviewregistry596).

A comprehensive literature search was conducted through Medline, Embase, Scopus, Web of Science, Dare, Cochrane library, and HTA database from January 2007 through June 2017. The purpose of this literature search was to identify eligible studies on fracture incidence following bariatric surgery. Conference abstracts and any grey literature was considered for eligibility. Database appropriate search terms, including “gastric bypass,” “sleeve gastrectomy,” and “fracture” were used as search terms. The search was limited to articles written in the English language. In addition, the reference lists of all eligible manuscripts were cross-referenced and any potentially relevant papers that may have been missed were added for analysis. The specific purpose of the search was to identify all published studies reporting on fracture incidence following bariatric surgery.

### 2.2. Selection criteria

Given the scarcity of high-quality scientific evidence on the subject matter, all human prospective or retrospective studies, non-randomized comparison studies, case series involving more than ten patients and abstracts presented at scientific conferences were considered for inclusion. Case reports, expert opinions and reviews were excluded. Studies needed to report on incidence of fracture following bariatric surgery. The target patient population were adults ( $\geq 18$  years) who underwent surgical management of their obesity by either; RYGB, BPD, AGB, or Sleeve Gastrectomy.

### 2.3. Data abstraction

All titles and abstracts were independently screened by two authors (GM and JBM) to determine whether they were pertinent

to the intended purpose of this systematic review. In the rare instances of a disagreement, the senior author (RG) resolved the disagreement. For all the selected titles, complete manuscripts were retrieved and reviewed. Again, the manuscripts were reviewed independently and accepted for inclusion in our study if they met the inclusion. Of all the full manuscripts reviewed, eight studies were accepted into the study. Their reference lists were cross-referenced to capture any additional studies which may have been missed by our initial search.

### 2.4. Study quality assessment

We used the Newcastle-Ottawa Scale (NOS) to assess the methodological quality of the studies included in the study [16]. This scale is a checklist with eight items that consists of three quality components: selection, comparability and outcome. Each item can be scored as one or two points and summed up to a total score, ranging from 0 to 9, with a higher score indicating low risk of bias, or better quality.

### 2.5. Statistical analysis

For the review, synthesis of mean, range, and average percentages across studies was used to describe the effectiveness of the intervention. A meta-analysis could not be performed due to the heterogeneity across studies included in our review.

## 3. Results

After removing duplicates and any study not written in English, a total of 135 titles were identified from the initial search. Of those, 124 were excluded, failing to meet the inclusion criteria. The remaining 11 studies had their manuscript reviewed in their entirety for consideration in the study. Three articles were subsequently excluded, based on lack of primary data. This search strategy and its results is demonstrated in Fig. 1.

This systematic review includes eight studies ( $n = 42,567$  subjects) [8,11,17–22]. No randomized controlled trials were identified. Seven retrospective cohort studies and one sub-study of the STAMPEDE trial were included for analysis. The average patient age was  $43.3 \pm 4.98$  years and 24.9% of patients were male (Table 1). All included studies had a minimum follow-up of 2 years; ranging from 2 to 7.7 years. Average follow-up time of the eight studies was  $3.7 \pm 1.96$  years. 1960 (4.6%) patients suffered at least one fracture during follow-up from their bariatric surgery. This systematic review included 42,567 patients with 2326 fractures. All baseline study characteristics are shown in Table 1.

The incidence of fracture following a specific bariatric surgery was of special interest. In the case that a study did not specify the type of bariatric surgery performed in patients who suffered a fracture, the authors attempted to contact the corresponding author in order to obtain the information.

Following this adjustment, 38,685 patients (3882 patients from Douglas et al. were omitted since the authors could not provide the specific type of surgery associated with the fractures reported) were included for further analysis. Of these 14,675 (38%) underwent RYGB. Of these, 391 suffered a fracture(s) (2.66%). For the purpose of this systematic review, patients who underwent AGB and sleeve gastrectomy had to be combined and renamed *restrictive bariatric procedures*, given the heterogeneity of result across studies and to facilitate data analysis. 18,417 patients were identified as having undergone restrictive bariatric procedures. Of these, 1051 (5.71%) suffered a fracture following their bariatric surgery. Finally, of the 1988 patients who underwent BPD surgery, 212 (10.66%) sustained at least one fracture.

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