ROLE OF PROBIOTICS AFTER BARIATRIC SURGERY

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Abstract
Obesity remains a global public health challenge, with bariatric surgery (BS) emerging as an effective intervention for morbid obesity when conservative treatments fail. BS procedures like Roux-en-Y Gastric Bypass (RYGB) and Laparoscopic Sleeve Gastrectomy (LSG) not only facilitate substantial weight loss but also alter the gastrointestinal (GI) tract's anatomy and physiology, influencing the composition of the gut microbiota. The gut microbiota plays an important role in host metabolism, energy regulation, and nutrient absorption, and its dysbiosis has been linked to obesity and related comorbidities. This review examines the impact of BS on gut microbiota and explores the role of probiotics in postoperative outcomes. Several randomized controlled trials have demonstrated that probiotics can improve GI function by reducing symptoms like bloating, gas, and abdominal pain. They also enhance metabolic profiles by significantly reducing fasting blood sugar, HbA1C levels, and inflammatory markers like TNF-α. Additionally, probiotics have been associated with increased levels of essential nutrients such as vitamin B12 and vitamin D, vital for postoperative recovery. Some studies suggest that probiotics may contribute to weight loss and reductions in waist circumference, especially when combined with weight loss programs and cognitive behavioral therapy. They may also positively influence plasma metabolites and markers related to nonalcoholic fatty liver disease (NAFLD). However, the effects of probiotics on body mass index (BMI), percentage of excess weight loss (%EWL), and the development of small intestine bacterial overgrowth (SIBO) remain inconclusive. The benefits observed in metabolic and nutritional parameters do not always persist after the cessation of probiotic supplementation, highlighting the need for continuous intervention and further research.

Keywords: *Bariatric surgery, Probiotics, Gut microbiota, Obesity, gastric bypass*

Introduction

Obesity and its associated comorbidities pose a significant public health challenge. The conservative treatments like lifestyle interventions for obesity often results in limited success [1, 2]. Bariatric surgery (BS) is currently the most effective method for managing morbid obesity, Roux-en-Y Gastric Bypass (RYGB) and Laparoscopic Sleeve Gastrectomy (LSG) being the most commonly performed procedures [3]. Given that BS alters the anatomy and physiology of the gastrointestinal (GI) tract, it can also influence the composition of the GI microbiota [2].

The GI microbiota consists of all the living microorganisms that inhabit the GI tract of a host organism [4]. These microorganisms exist in a complex, mutually beneficial relationship with the host, and play an important roles in defending against external pathogens. They also maintain optimal intestinal physiology, regulate weight and energy metabolism, metabolize nutrients and drugs, and produce metabolites like short-chain fatty acids (SCFAs) involved in appetite regulation [5]. SCFAs contribute to 5–10% of the host's energy requirements and influence satiety hormones such as Peptide YY through enteroendocrine cells and the gut–brain axis, potentially affecting appetite control [1, 6, 7]. Dysbiosis of the GI microbiota has been linked to various pathological conditions, including immune disorders, obesity, type 2 diabetes mellitus, inflammatory bowel diseases, increased susceptibility to infections, and hepatic and neurological disorders [8].

BS has proven to be highly effective in achieving substantial and sustainable weight loss for individuals with obesity. The global prevalence of overweight and obesity has reached alarming levels, posing significant challenges to health systems worldwide [9]. These conditions are characterized by abnormal or excessive fat accumulation, adversely affecting an individual's overall health and quality of life [9]. In addition to facilitating weight loss, bariatric surgery resolves obesity-related comorbidities and significantly improves patients' quality of life. Numerous studies have highlighted its remarkable benefits in enhancing overall health and well-being. Successful outcomes in bariatric surgery depend on a comprehensive multidisciplinary approach. This involves preoperative evaluation, careful patient selection, comprehensive postoperative care, nutritional support, and psychological counseling. Regular follow-up and adherence to postsurgical recommendations are important for sustaining weight loss and achieving positive long-term results. Studies indicate that BS leads to significant alterations in gut microbiota composition, often increasing microbial diversity and affecting the abundance of key bacterial phyla such as Firmicutes and Bacteroidetes. Probiotic supplementation post-BS has shown promising yet varied outcomes across multiple studies.

Types of Bariatric Surgery Procedures

These are physiologically of two types : Restrictive and Malabsorptive. In the former, the size of stomach is reduced by various methods, restricting the amount of food that can be eaten. In malabsorptive operations, the digestive tract is anatomically altered in such a way that the number of calories absorbed is reduced. The two types can also be combined to achieve maximal weight-loss in highly obese individuals.

Sleeve Gastrectomy (SG)

Laparoscopic Sleeve Gastrectomy (LSG) is a restrictive bariatric procedure that reshapes the stomach into a narrow, tubular structure, called a " sleeve". [10, 11]. The stomach is freed from surrounding structures, and approximately 80% of the stomach is removed. (Figure 1). LSG induces weight loss by reducing gastric volume, altering hormonal levels (particularly ghrelin and peptide YY), and changing gastric motility [12,13]. Besides causing weight loss, there is improvement in comorbidities like type 2 diabetes mellitus (T2DM) and hypertension. By retaining normal physiology, this causes minimal disturbance in gut microbiome.

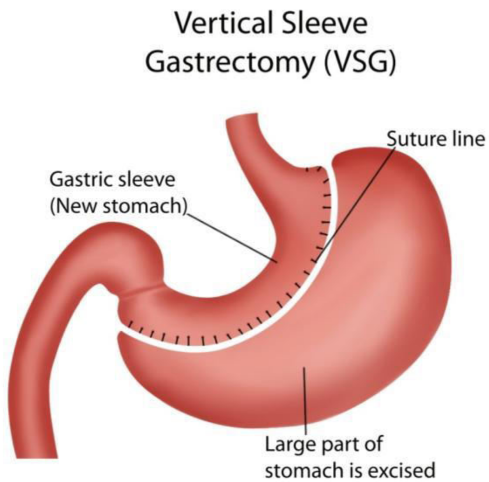

Figure 1. A major part of the stomach around the greater curvature is removed, leaving a small gastric pouch

Gastric Bypass (Roux-en-Y)

This is one of the commonest surgical procedures performed for morbid obesity, and besides being very effective in achieving weight loss, it is also effective in diminishing co-morbid conditions, especially diabetes mellitus [14]. In this operation, the stomach is divided into a smaller top portion (pouch) which is about the size of an egg. The larger part of the stomach is bypassed and can no longer store food since it is separated from the pouch. The small intestine is then divided around 90 cms from the D-J flexure, and connected to the new stomach pouch. Thence, the food passes directly into the small intestine from the egg-sized stomach pouch. This small bowel segment which empties the bypassed or larger stomach is then connected to the proximal small bowel approximately 3-4 feet downstream, resulting in a bowel connection resembling the shape of the letter Y (Figure 2). Physiologically, the stomach acids and digestive enzymes from the bypassed stomach and first portion of the small intestine will reach the distal portion and mix with the food that is eaten. Roux-en-Y gastric bypass (RYGB) results in significant body weight loss due to reduced food intake, nutrient limitations, and potentially altered metabolic efficiency [14]. By altering the physiology of digestion, there occur significant alterations to the gut microbiome.

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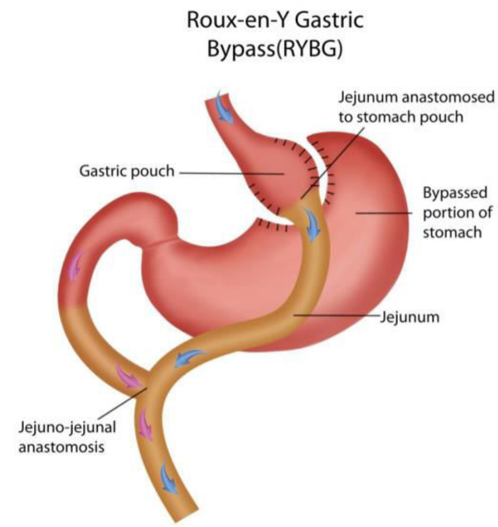

Figure 2. Primarily a restrictive procedure, where the small gastric pouch allows a food intake of only 50-100ml.

Adjustable Gastric Banding (Lap-Band)

In the Adjustable Gastric Banding (Lap-Band) procedure, a silicone device is placed around the top part of the stomach, to limit the amount of food that a person can consume. The adjustable gastric band induces weight loss by promoting early satiety and reducing appetite, impacting esophageal and proximal gastric functions through the vagus nerve [15,16]. This procedure, though comparatively safe and simple, is roughly as effective as a sleeve gastrectomy.

Biliopancreatic Diversion with Duodenal Switch (BPD/DS)

The biliopancreatic diversion procedure involves three main components: creating a stomach tube while preserving the pylorus, performing distal ileoileal anastomosis, and establishing proximal duodenal-ileal anastomosis [13]. Initially, a sleeve gastrectomy is performed, followed by

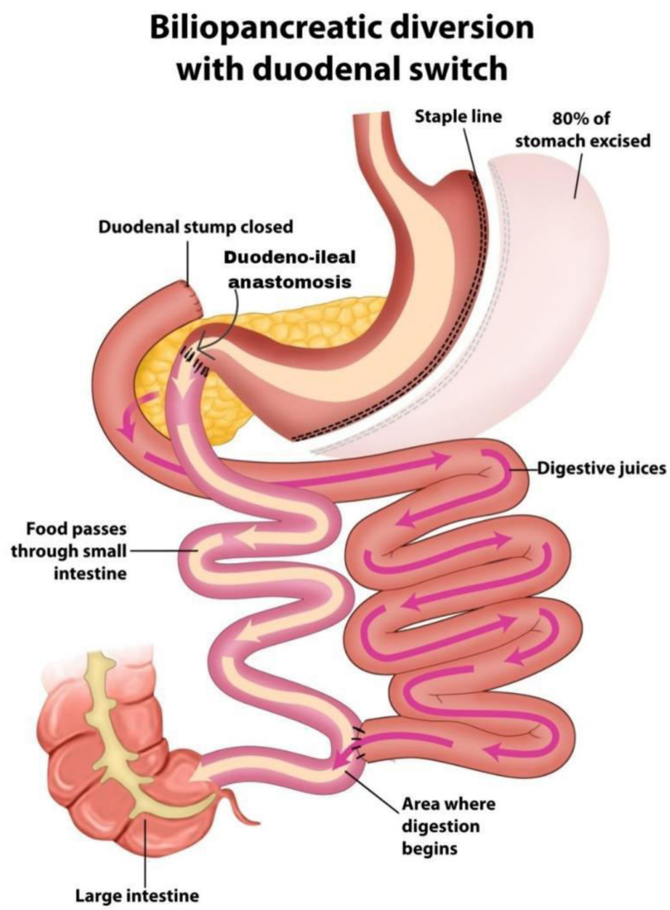

Figure 3. A combination of restriction and malabsorption, it offers the best results. The digestive and absorptive segment is only about 5 feet, considerably reducing nutrients and calories absorbed.

transection of the small bowel 250 cm proximal to the ileocecal valve. The alimentary limb (gastric pouch alongwith proximal part of duodenum) is anastomosed to the transected portion of the ileum to form the duodenoileal anastomosis, and an ileoileal anastomosis is created 150 cm (5 feet) proximal to the ileocecal valve, effectively reducing the length where digestion occurs to around 5 feet [13, 17]. Biliopancreatic diversion into a very small length of ileum results in early weight loss due to the sleeve gastrectomy and long-term weight loss from fat malabsorption. Hormonal changes, including reduced ghrelin and increased peptide YY levels, lead to early satiety. Gastrectomy affects ghrelin levels, while rapid nutrient entry into the ileum after the distal bypass increases peptide YY levels [13]. Despite being less common than other bariatric procedures, biliopancreatic diversion achieves impressive long-term weight loss, approximately 70% %EWL [18]. In terms of alterations in gut microbiota, this procedure causes maximum disruption and disturbance.

Single Anastomosis Gastric Bypass-Mini Gastric Bypass (OAGB-MGB) surgery

This operation is a rapid, safe and effective bariatric operation The operation consists of two steps.

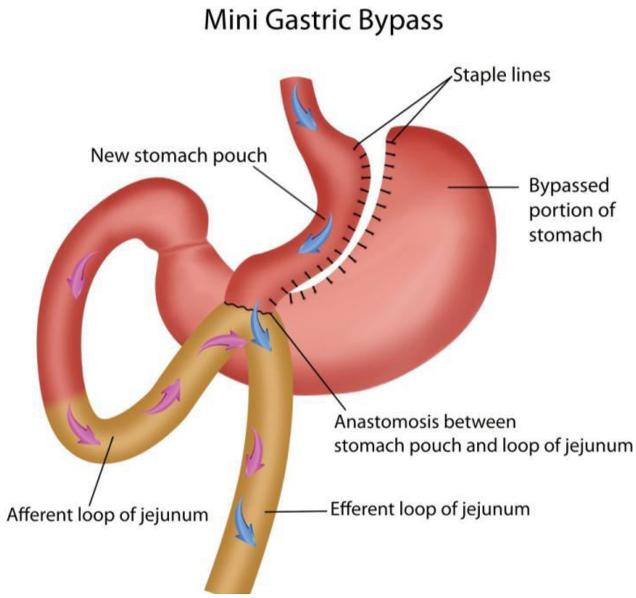

Figure 4. The re-fashioned small gastric pouch is anastomosed to a loop of jejunum, approximately 5 feet away from the duodenum.

First, a long and narrow gastric pouch is created along the lesser curvature, separating the major portion of the stomach from this gastric pouch. Second, an antecolic gastro-jejunal (GJ) anastomosis (GJ) is carried out, anastomosing the small gastric pouch to a loop of the jejunum around 200 cm from the duodeno-jejunal junction, effectively creating a gastro-jenunal bypass. This leads to significant (fat) malabsorption, since the digestive enzymes come into contact with the food only distal to the anastomosis. This procedure significantly disturbs the gut microflora by bypassing the stomach and duodenum, thereby altering the physiology.

Gut microbiota and Obesity

Various studies have reported a potential association between obesity and imbalanced proportions of two dominant bacterial phyla of the gut microbiome: Firmicutes and Bacteroidetes. Notable alterations at the genus level have been documented in the gut microbiota of obese patients compared to those having normal weight [20-28].The studies demonstrated that the gut microbiota of obese individuals often showed an increased proportion of Firmicutes and a decreased proportion of Bacteroidetes [19-21].

These changes suggest that gut dysbiosis is closely associated with obesity. The mechanisms underlying the role of gut microbiota in obesity include increased energy absorption and lipid synthesis, chronic inflammation leading to impaired insulin function, and modulation of central appetite signals and feeding behavior. Dysbiosis can alter the metabolite profile, leading to increased production of short-chain fatty acids (SCFAs), which contribute to energy harvest and fat accumulation [29]. Overgrowth of lipopolysaccharide (LPS)-producing Gram-negative bacteria can trigger chronic low-grade inflammation, promoting insulin resistance and obesity [29]. Studies have found that obese children have a higher proportion of Firmicutes and a lower proportion of Bacteroidetes in their gut microbiota [30]. One research study involving the Ukrainian population revealed that the Firmicutes/Bacteroidetes ratio increased in conjunction with higher body mass index (BMI) [21].

However, some recent studies have shown contradictory findings regarding this ratio. Zhang et al. [31] did not find significant differences in Bacteroidetes abundance between obese and normal-weight individuals. An analysis using data from the American Gut Project, which included 1,655 healthy and 898 obese adults, showed that the Firmicutes/Bacteroidetes ratio was actually lower in obese individuals [32]. These variations are possibly due to factors such as ethnicity, lifestyle variations, dietary habits, and methodological differences [22,23].

Interestingly, the family Christensenellaceae has been linked to weight loss, with its relative abundance inversely related to host BMI [33]. Akkermansia muciniphila, in particular, is notable for its role in weight management; supplementation with this bacterium has been shown to improve metabolic parameters in overweight and obese individuals [34]. Moreover, Lactobacillus and Bifidobacterium, traditional probiotics essential for maintaining gut microbial balance, have species-specific effects on body weight. Crovesy et al. [35] reported that while the abundance of *Lactobacillus paracasei* is negatively correlated with obesity, *L. reuteri* and *L. gasseri* are significantly associated with obesity. Million et al. [36] found that *Methanobrevibacter smithii* and *Bifidobacterium animalis* were associated with normal weight, whereas *L. reuteri* was associated with obesity. Probiotics have shown promising effects in reducing visceral obesity. In patients with nonalcoholic fatty liver disease, a probiotic mixture containing *L. acidophilus*, *L. rhamnosus*, *L. paracasei*, *Pediococcus pentosaceus*, *B. lactis*, and *B. breve* has been reported to significantly reduced BMI and intrahepatic fat fraction after 12 weeks of administration, with increased abundance of these probiotic flora observed in the gut [37]. These findings highlight that the impact of gut microorganisms on obesity is strain-specific, and even bacteria within the same genus can have opposite effects, likely due to the complex metabolic pathways involved in obesity.

Altered Gut Microbiome after Bariatric Surgery

Numerous research studies have shown the impact of bariatric surgery on microbiota and the effects of probiotic use after Bariatric Surgery (BS). A systematic review in 2022 revealed that while the predominance of intestinal bacterial phyla varied among studies, a general trend showed an increase in microbial diversity post-surgery [38]. Most studies reported a greater abundance of Bacteroidetes and Proteobacteria following BS. The Firmicutes-to-Bacteroidetes (F/B) ratio presented inconsistent results—some studies observed increases, others a decrease—after Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG). However, a common finding was a reduction in the relative proportion of Firmicutes. Additionally, an elevated proportion of

Actinobacteria was observed specifically after RYGB, a change not identified when SG procedures were applied.

Variations in genera abundance and bacterial predominance were noted according to the surgical procedure, with limited data regarding impacts at the phylum level. These studies suggest that BS leads to significant alterations in gut microbiota composition, which may contribute to metabolic improvements and weight loss in obese individuals. Li, J.V. et al. (2021) found that RYGB induced the greatest weight loss and most profound metabolic and bacterial changes compared to Sleeve Gastrectomy (SG) and laparoscopic gastric banding (LGB) [39]. Post-RYGB patients exhibited increased host-bacterial co-metabolism of aromatic amino acids, evidenced by elevated urinary excretion of metabolites such as 4-hydroxyphenylacetate, phenylacetylglutamine, 4-cresyl sulfate, and indoxyl sulfate, as well as increased fecal excretion of tyramine and phenylacetate. There was also increased bacterial degradation of choline, indicated by altered urinary trimethylamine-N-oxide and dimethylamine excretion and higher fecal concentrations of dimethylamine.

Cultured bacteria from RYGB patients showed a greater capacity to produce tyramine from tyrosine, phenylacetate from phenylalanine, and indole and tryptamine from tryptophan, compared to microbiota from non-surgery, normal-weight individuals. Additionally, disruptions were observed in 3-hydroxydicarboxylic acid metabolism, urinary excretion of primary bile acids, serum branched-chain amino acids, and dimethyl sulfone levels following BS. These results suggest that the altered bacterial composition and metabolism after RYGB contribute significantly to metabolic changes observed in patients, potentially influencing the surgery's effectiveness in inducing weight loss and improving metabolic health.

Further, Novljan, U and his colleague in 2022 evaluated the incidence of small intestinal bacterial overgrowth (SIBO) following bariatric bypass surgeries [40]. They found that out of 56 patients, 43% tested positive for SIBO, indicating an alarmingly high incidence post-surgery. SIBO was associated with a higher frequency of defecation, lactose intolerance, scleroderma, irritable bowel syndrome, and diabetes. Additionally, SIBO was related to a reduced response to the application of low molecular weight heparin (LMWH), suggesting that SIBO may affect medication efficacy. The study concluded that due to the high incidence and nonspecific symptoms of SIBO after bariatric surgery, mandatory screening and appropriate treatment are essential. Wagner et al also reported a strong connection between microbiota shifts and metabolic health improvements post-surgery [41]. These changes are associated with alterations in gastrointestinal flow, lower acidity, and dietary shifts post-surgery. Studies also suggest that the use of probiotics postoperatively can alleviate gastrointestinal symptoms, enhance vitamin B12 synthesis, and promote weight loss, indicating a potential therapeutic benefit for patients undergoing bariatric surgery.

Another research study investigated the relationship between gut microbiota composition and weight loss outcomes in patients undergoing sleeve gastrectomy [42]. They assessed gut microbiota of seventy-six patients before surgery and three months afterward. The participants were divided into two groups based on their excess weight loss (%EWL) one year post-surgery: responders (>50%EWL) and non-responders (<50%EWL). The results showed that preoperative microbiota composition, particularly the Prevotella-to-Bacteroides ratio, was significantly different between responders and non-responders. After surgery, responders had an increase in beneficial metabolic taxa. These findings suggest that gut microbiota could predict weight loss outcomes and influence post-surgery metabolic improvements. Collectively, these studies highlight that bariatric surgery, especially RYGB, leads to significant alterations in the gut microbiota's composition and diversity. There is a general trend toward increased microbial diversity and shifts in the abundance of major bacterial phyla such as Bacteroidetes, Proteobacteria, Firmicutes, and Actinobacteria. These microbial changes are associated with alterations in metabolic functions, including enhanced host-bacterial co-metabolism of aromatic amino acids, altered choline metabolism, and disruptions in bile acid pathways. The gut microbiota after RYGB surgery exhibits a greater capacity to produce bioactive compounds from amino acids, which may influence host physiology and contribute to the metabolic improvements and weight loss observed post-surgery. However, bariatric surgery may also increase the risk of complications like SIBO, which can affect nutrient absorption, medication efficacy, and overall health. The high incidence of SIBO post-surgery highlight the need for routine screening and management to improve patient outcomes.

Role of probiotics following bariatric surgery

Probiotics

Though the scope and appropriate use of the term "probiotic" has undergone modifications over the past few decades, the World Health Organization (WHO), in a 2001 report defined probiotics as "live microorganisms which when administered in adequate amounts confer a health benefit on the host." [43,44)]**.** In October 2013, a group of scientific experts assembled in Canada, and reinforced this definition as relevant and sufficiently accommodating for current and anticipated applications [45].

Probiotics are available in fermented food products that contain lactic acid bacteria. These include dairy products such as yogurt and buttermilk, and non-dairy products such as bee pollen, pickled vegetables and sourdough bread. Bread-like products made without wheat or rye flour, amino acid/peptide meat-flavored sauces and pastes produced by fermentation of cereals and legumes also contain probiotics. Plengvidhya et al, in their 2007 study, found that Sauerkraut, which is finely cut raw cabbage that has been fermented, contains the bacteria Leuconostoc mesenteroides, Lactobacillus plantarum, Lactobacillus brevis, Leuconostoc citreum, Leuconostoc argentinum, Lactobacillus paraplantarum, Lactobacillus coryniformis, and Weissella spp [46]. Buttermilk contains either Lactococcus lactis *or L. bulgaricus.*

Benefits of Probiotic use following Bariatric Surgery

Various research studies have shown the impact of probiotic consumption after bariatric surgery. Woodard et al. investigated the impact of probiotic administration on gastrointestinal outcomes and weight loss in patients undergoing Roux-en-Y gastric bypass (RYGB). In a randomized, controlled trial of 44 participants, those receiving probiotics daily showed significant improvements in **bacterial overgrowth**, excess weight loss, and vitamin B12 levels compared to the control group [47]. The probiotic group experienced greater percent weight loss at 6 weeks, 3 months, and 6 months, alongside higher postoperative vitamin B12 levels. They suggested that probiotics may positively influence gastrointestinal flora, aiding in weight loss and nutrient absorption post-RNYGB.

In 2021, a systematic review and meta-analysis by Zhang et al. analyzed the effects of probiotics on weight loss, BMI, waist circumference (WC), and C-reactive protein (CRP) in adults with obesity post-bariatric surgery (BS) [48]. The study evaluated data from four randomized controlled trials, including 172 participants. While probiotics demonstrated a statistically significant reduction in WC at 12 months post-BS, they showed no significant impact on BMI, weight loss, %EWL, or CRP. They concluded that while probiotics may aid WC reduction, further research is required to assess their broader efficacy as an adjunct to BS. Further, in a detailed double-blind, randomized clinical trial led by Hamid Melali et al., 135 Roux-en-Y gastric bypass (RYGB) patients were studied to assess the effects of probiotic supplementation on gastrointestinal function, vitamin levels, and metabolic status [49]. At both 3 and 6 months post-surgery, results showed that while BMI was reduced in both groups, the probiotic group exhibited significantly improved **metabolic markers,** including fasting blood sugar (FBS) and HbA1C. FBS levels in the probiotic group decreased markedly at 3 months ($P=0.02$) and even more so at 6 months ($P<0.001$), compared to the placebo group. Similarly, HbA1C levels in the probiotic group dropped significantly at 3 months ($P=0.001$) and 6 months ($P<0.001$). Also, vitamin B12 levels were substantially increased in the probiotic group ($P<0.001$), with the probiotic group maintaining notably higher levels than the placebo group throughout the study. The Gastrointestinal Quality of Life Index (GIQLI) also revealed improved GI symptoms in both groups, with a more significant improvement observed in the probiotic group ($P<0.001$). These findings showed that while probiotic supplements did not have a notable effect on weight loss, they enhanced patients' vitamin B12 levels, metabolic profile, and gastrointestinal function after RYGB surgery.

In another randomized, triple-blind, placebo-controlled study, the impact of probiotic supplementation in conjunction with a weight loss program and cognitive behavioral therapy (CBT) on **patients with food addiction and weight regain** after bariatric surgery were investigated [50]. The probiotic group experienced significant improvements in weight, fat mass, BMI, eating behavior, and food addiction compared to the placebo group. Notably, leptin levels decreased, while oxytocin levels increased in the probiotic group. These findings suggest that probiotics enhance the effectiveness of a weight loss program and CBT in managing food addiction and weight regain. Moreover, in a placebo-controlled, double-blind, randomized clinical trial, the effects of probiotic supplementation were investigated in morbidly obese patients undergoing One Anastomosis Gastric Bypass-Mini Gastric Bypass (OAGB-MGB) surgery [51]. The outcomes showed that probiotic supplementation led to significant improvements in serum inflammatory markers, vitamin D levels, and weight loss compared to the placebo group. Additionally, glycemic indices and lipid profiles improved in both groups, but no differences were observed in vitamin B12, folate, or homocysteine levels. The findings suggested that probiotics may enhance some outcomes post-surgery, though longer-term effects require further study.

Further, Chen, J. C. et al. [52] evaluated the effect of probiotics and digestive enzymes on **gastrointestinal symptoms** in patients after gastric bypass surgery in a double-blind, randomized trial. They found improvements in GI-related quality of life, including reductions in flatulence, bloating, heartburn, and abdominal pain, across all groups. The outcomes suggested that probiotics alongwith digestive enzymes may help alleviate symptomatic GI episodes and improve quality of life following gastric bypass surgery. Another randomized, double-blind, placebo-controlled clinical trial by Ramos, M. et al. investigated the impact of probiotic supplementation on plasma metabolites following Roux-Y gastric bypass (RYGB) [53].The patients were divided into probiotic and placebo groups, with the probiotic group receiving *Lactobacillus acidophilus* NCFM and *Bifidobacterium lactis* Bi-07 for 3 months. The outcomes showed significant reduction in trimethylamine-N-oxide (a harmful metabolite), and an increase in β-hydroxybutyrate (a useful energy source), in the probiotic group compared to placebo. These changes suggested that probiotics may positively influence metabolic health by altering plasma metabolites post-RYGB.

Interestingly, studies also show that the gut microbiota plays a role in **inflammation** and physiological complications after bariatric surgery (BS). However, using probiotics has been suggested as being beneficial since probiotics help regulate inflammation, oxidative stress, and micronutrient levels. Research indicates that probiotics may support weight loss, food tolerance, and quality of life post-Roux-en-Y gastric bypass (RYGB) [54]. Further, Crommen et al. in 2022 examined the effect of a specially formulated multistrain probiotic and micronutrient mixture on **NAFLD** (nonalcoholic fatty liver disease) markers in obese patients after mini gastric bypass (MGB) surgery [55]. In a 12-week, double-blind, randomized trial, 48 patients were analyzed. The probiotic and micronutrient group showed significant improvements in serum aspartate aminotransferase (ASAT), NAFLD fibrosis score, serum triglycerides, and visceral adiposity index compared to a control group receiving basic care micronutrients. However, there was no difference in serum alanine aminotransferase (ALAT) levels between groups. These findings revealed the beneficial outcomes of probiotic consumption after bariatric surgery for NAFLD-related outcomes. Also, Mokhtari et al. [56] investigated the impact of probiotics on various blood markers and weight loss in morbidly obese patients undergoing one-anastomosis gastric bypass (OAGB). The double-blind, placebo-controlled trial included 46 patients randomized to receive probiotic or placebo supplements for four months, with nine months of follow-up. The outcomes showed that probiotics improved levels of **lipopolysaccharides-binding protein** (LBP), TNF-α, vitamin B12, vitamin D3, and promoted weight loss after four months. However, most benefits did not persist nine months after treatment ceased, except for reduced malondialdehyde (MDA) levels.

Also, Ramos and his colleagues [57] in a randomized, double-blind, placebo-controlled clinical trial examined the effects of *Lactobacillus acidophilus* and *Bifidobacterium lactis* supplementation on patients after Roux-en-Y gastric bypass (RYGB). Over three months, patients either received probiotic supplements or a placebo. The results showed that probiotic supplementation significantly increased **vitamin D and** vitamin B12 levels, and lowered triglyceride levels. Both groups showed improvements in anthropometric parameters and glycemic profiles, but the probiotic group exhibited superior outcomes in lipid and vitamin profiles. These outcomes suggest that probiotics can enhance metabolic and nutritional outcomes post-RYGB surgery. Another randomized, double-blind, placebo-controlled trial by Wagner, et al. investigated the effects of *Lactobacillus acidophilus* and *Bifidobacterium lactis* supplementation on gastrointestinal symptoms and small intestine bacterial overgrowth (SIBO) in patients post-Roux-en-Y gastric bypass (RYGB) [58]. Over 90 days, the probiotic group reported less bloating but experienced more soft stools and nausea compared to the control group. The prevalence of SIBO remained unchanged, and while bloating was reduced, gastrointestinal symptom scores did not differ significantly between groups. They concluded that probiotics may alleviate bloating but do not impact SIBO development in the early postoperative period.

Conclusion

In conclusion, probiotics after bariatric surgery show promising yet varied outcomes across multiple studies. Probiotic supplementation has been associated with improvements in gastrointestinal function—reducing symptoms like bloating, flatulence, and abdominal pain—and enhancing metabolic profiles, including significant reductions in fasting blood sugar, HbA1C levels, and inflammatory markers such as TNF-α. Additionally, probiotics have been linked to increased levels of vital nutrients like vitamin B12 and vitamin D, which are essential for postoperative recovery. Some studies indicate that probiotics may contribute to weight loss and reductions in waist circumference, especially when combined with weight loss programs and cognitive behavioral therapy, and may positively influence plasma metabolites and markers related to nonalcoholic fatty liver disease (NAFLD). However, the impact of probiotics on body mass index (BMI), percentage of excess weight loss (%EWL), and the development of small intestine bacterial overgrowth (SIBO) remains inconclusive. The benefits observed in some metabolic and nutritional parameters did not always persist after the cessation of probiotic supplementation, highlighting the need for continuous intervention and further research. Larger, long-term randomized controlled trials are necessary to fully understand the efficacy and safety of probiotics as an adjunct therapy after bariatric surgery, and clinicians should consider these findings cautiously while monitoring emerging research to inform their postoperative care strategies.

Abbreviations BS – Bariatric Surgery, LGB -- laparoscopic gastric banding, NAFLD -- Nonalcoholic fatty liver disease, SIBO --small intestine bacterial overgrowth, RYGB -- Roux-en-Y gastric bypass, ASAT – (serum) aspartate aminotransferase, %EWL – Percentage Excessive weight loss**,** One Anastomosis Gastric Bypass-Mini Gastric Bypass (OAGB-MGB)

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