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INTEGRATED STUDY MASTER'S THESIS

Gastric plication for weight loss

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1. List of abbreviations

Abbreviations	Definition
ASMBS	American Society for Metabolic and Bariatric Surgery
LGGCP	Laparoscopic gastric greater curvature plication
LSG	Laparoscopic sleeve gastrectomy
RYGB	Roux-en-Y gastric bypass
AGB	Adjustable gastric banding
BMI	Body Mass Index
EWL	Excess Weight loss
TWL	Total weight loss
EBMIL	Excess BMI loss
CAD	Coronary Artery Disease
AHT	Arterial Hypertension
DJD	Degenerative joint disease
OSA	Obstructive sleep apnoea
T2DM	Type 2 Diabetes Mellitus
GERD	Gastroesophageal reflux disease
FL	Fatty liver
NAFLD	Non-alcoholic fatty liver disease
JIB	Jejunoileal bypass
VGB	Vertical banded gastroplasty
PYY	Peptide tyrosine tyrosine
GCG	Glucagon
BDNF	Brain-Derived Neurotrophic Factor
MBS	Metabolic and Bariatric surgery

2. Abstract

Background: Obesity is a global health issue with its prevalence continuously rising. Therefore, bariatric surgery is gaining attention and relevance as a therapeutic intervention. A relatively new procedure compared to the more established surgical techniques, such as sleeve gastrectomy or Roux – en – Y – Gastric Bypass, is called gastric plication. It is showing promising results in regard to sustained weight loss and remission of obesity – related comorbidities. However, most of the existing literature is focussing on short term results, which is why mid to long term results will be the point of interest in this literature review.

Methods: Comprehensive online literature research was conducted on PubMed, Cochrane and google scholar for articles published from 2010 until 2024. Studies representing outcomes from gastric plication were included when reporting ≥ 3-year of gastric plication results. The studies had to include at least one relevant outcome – in terms of weight loss including either excess weight loss, total weight loss or excess body-mass-index loss, patient´s remission of obesity-related comorbidities and complications.

Results: In total 7 Studies (4 retrospective, 2 prospective case series and 1 Cohort Study), involving 1405 patients in total who underwent gastric plication, were included in the final analysis. Among the patients 78.5% were women and 21.5 % men. The mean age of the patients at the time of surgery was 38 years. The mean preoperative BMI was 39,82 kg/m2. The duration of follow up varied from 1 to 12 years. Two studies reported 3-year results, two studies reported 5-year results, one study showed 6-year results, another study presented up to 7-year results and another study reported up to 12-year results. Mean EWL% after 1, 3 and 5 years was 60.1%, 52.53% and 54.58% while mean TWL% was 24.79%, 18.85% and 19.33%. Mean EBMIL% at those time rates was 60.77%, 51.05% and 57.23%. Mean remission rates across all the studies were 73.11% for type 2 Diabetes Mellitus, 78% for patients with dyslipidaemia, 64.43% in arterial hypertension, 21% in gastroesophageal reflux disease reporting it only from one article, 78.33% for fatty liver such as 100% remission rate in obstructive sleep apnoea and degenerative joint diseases.

Conclusion: Gastric plication is showing promising results in terms of sustained weight loss and improvements in obesity-related comorbidities. Complication rates are comparable to other well-established bariatric surgery procedures such as sleeve gastrectomy. By reviewing the existing literature, it becomes evident that gastric plication is recognized as a noteworthy option.

Nevertheless, this procedure still lacks qualitative literature and studies especially for long-term results (>5 years). There is limited number of articles available so conducting a well-rounded conclusion for this procedure seems challenging for now. Furthermore, there is substantial heterogeneity among the included studies making comparisons to more established bariatric techniques challenging.

3. Keywords

Laparoscopic Gastric Plication, Bariatric Surgery, Weight Loss, Obesity

4. Introduction

4.1. Global obesity epidemic

Obesity has become an important global health issue with its prevalence steadily rising. In the U.S. the obesity rate has been particularly alarming in recent years. According to a report from the CDC in 2023 nearly one in three adults and one in six children are affected by obesity. In 2023, 41.9% of American adults were obese, which shows a significant increase from 30.5% only two decades ago. That results in a rise of over 10% in obesity rate. In children and adolescents, the prevalence of obesity was 19.7% meaning more than 14 million children are currently affected. This indicates an early exposure to health risks in the future. If this trend continues the World Obesity Atlas (WOA) predicts that more than half of the global population will be obese by 2035 indicating an international obesity issue. A BMI between 25 and 29 kg/m² is considered as overweight while a BMI over 30 kg/m² is classified as obesity. Since 1975, the global obesity rate has tripled (1)(2). As illustrated in Figure 1 obesity rates are increasing especially in Western societies with significant growth in North America, Europe, and parts of the Middle East. Meanwhile, developing nations such as India, Nigeria, and Indonesia still report lower obesity levels though they are experiencing a steady upward trend.

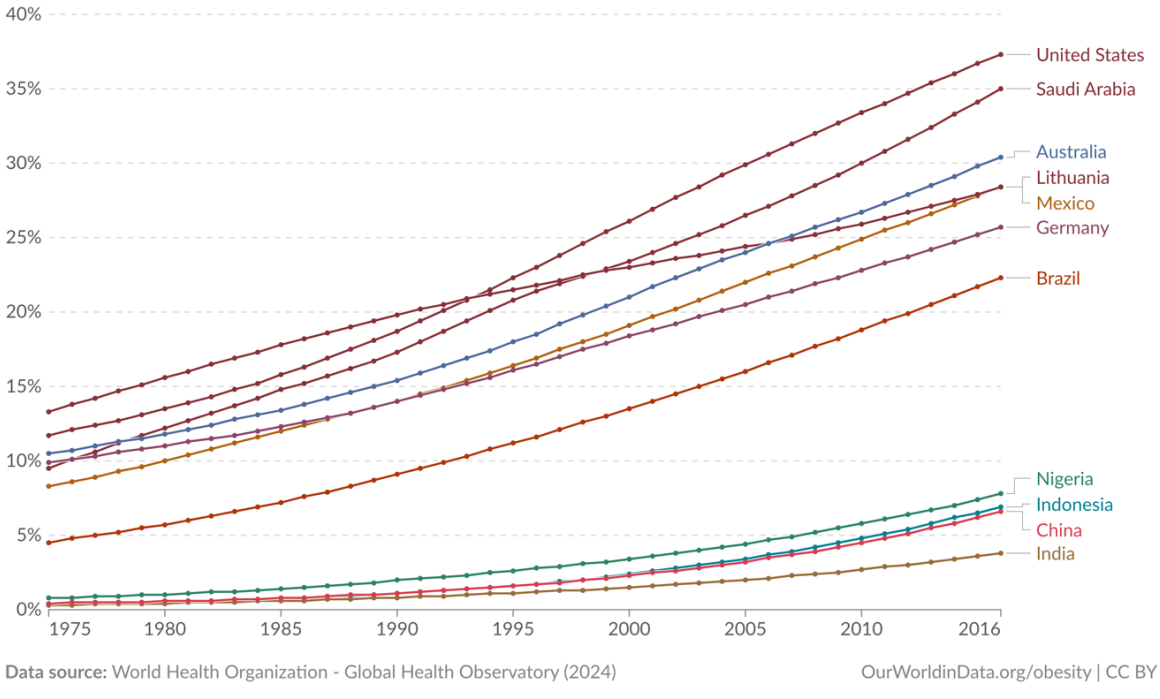

Figure 1 Obesity in adults (1975 - 2016) Estimated prevalence of obesity, based on general population surveys and statistical modelling (3)

4.2. Health risks of obesity

Given the alarming numbers in regard to obesity rates it is important to outline their main health risks which are summarized in figure 2. Individuals with obesity are at a higher risk of developing a range of serious health conditions including type 2 diabetes mellitus. It can lead to insulin resistance and β-cell dysfunction primarily due to chronic inflammation, increased free fatty acids, and adipokine dysregulation (4).

Excess adiposity contributes to dyslipidaemia, hypertension, and systemic inflammation which can cause atherosclerosis and as consequence increase the risk of CAD. It is also independently associated with an increased risk of cerebrovascular disease due to similar mechanisms affecting CAD (5).

Individuals affected by obesity are also associated with increased cholesterol saturation in bile and impaired gallbladder motility leading to a higher incidence of cholelithiasis and cholecystitis. Furthermore, it is also associated with respiratory conditions. Having increased parapharyngeal fat deposits and reduced lung volume contribute to obstructive sleep apnoea. Excess weight causes mechanical stress on joints leading to cartilage degradation and osteoarthritis (6).

Moreover, it is associated with major depressive disorder (MDD) through both psychological and biological mechanisms. The relationship between obesity and depression is well-documented with each condition increasing the risk of developing the other (7). Additionally, individuals with obesity are at an increased risk for certain cancers (8).

Studies showed that Adults with class III obesity or higher (BMI >40) experience a significant reduction in life expectancy potentially by up to 14 years. They are at an increased risk of premature death from conditions such as heart disease, diabetes or cancer (9).

The rising obesity rates are not only linked to health issues but also have significant economic implications. This public health crisis in the U.S. is directly associated with higher medical costs including inpatient, outpatient, and prescription drug expenses. Medical expenditures related to obesity were found to be higher among adults covered by public health insurance programs. This demonstrates the economic burden of obesity, particularly for those dependent on public healthcare with the national cost of obesity reaching up to $260.6 billion (10). This underlines the importance of interventions to prevent and reduce obesity, given its big economic impact and the associated increase in mortality and morbidity.

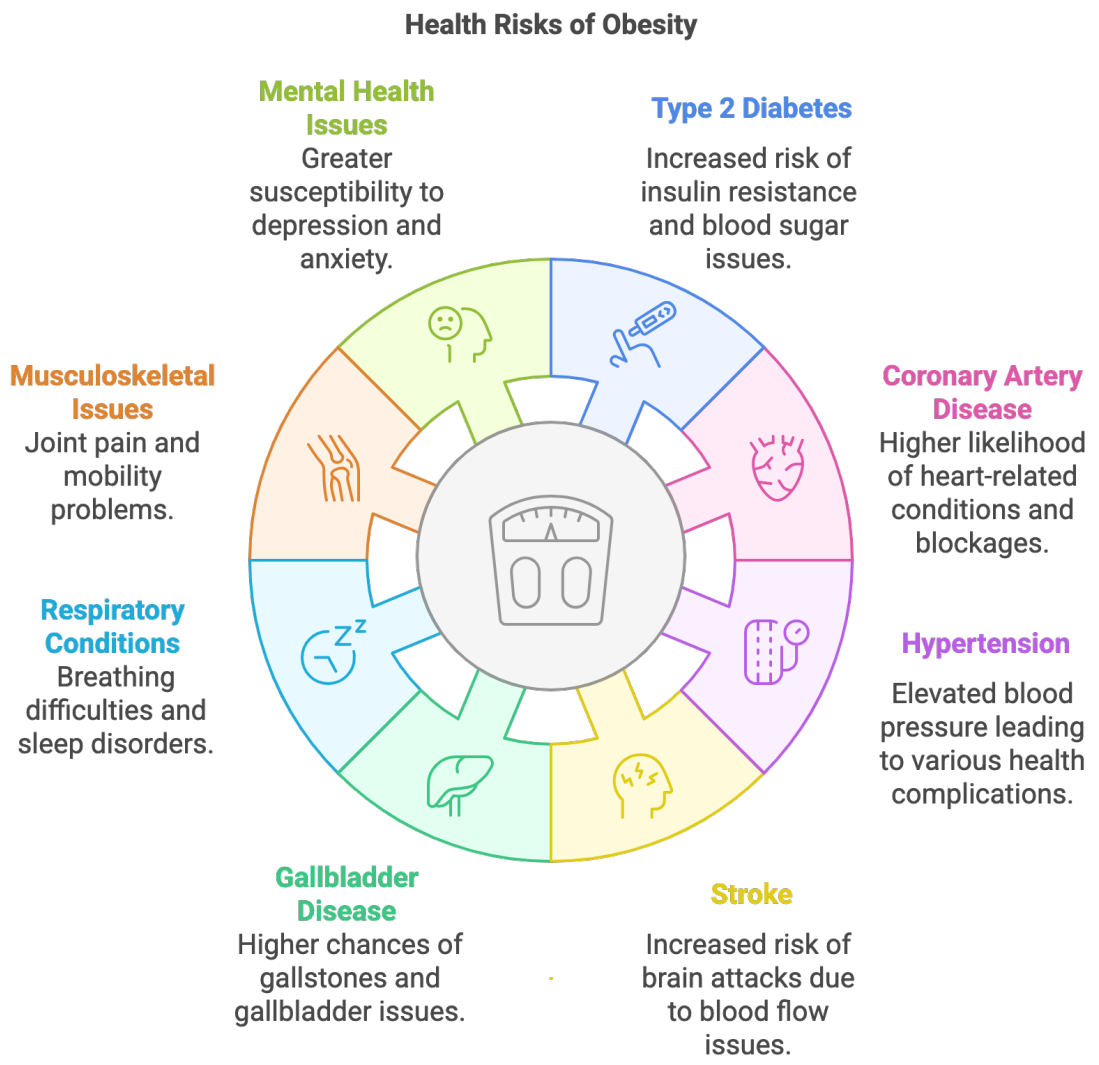

Figure 2 Demonstrating major health risks of obesity

4.3. Causes of obesity

Before moving on to various treatment options it is essential to first understand the underlying causes of the increasing obesity rates, which are demonstrated in figure 3. As with many complex issues obesity has several contributing factors. Until the 1980s its prevalence remained relatively low compared to today's figures but then raised significantly in the following decades after. During this period changes in the "built environment" such as the introduction of elevators and escalators led to a decline in overall physical activity. Additionally, development in technology influencing mobility in general and introducing for example televisions, video games and the internet further encouraged a more sedentary lifestyle.

In addition to the decline in physical activity the widespread availability of cheap, highly processed, and sugary foods further contributed to the rise in obesity rates. Before 1900 sugar was considered a rare luxury. In the early 1800s the average American consumed only 4–6 pounds of sugar per year,

which is a figure that has increased to 150–170 pounds annually. The food industry has increasingly relied on sugar as a cost-effective way to enhance flavour and raise sales. Both environmental and behavioural factors have contributed to what is now known as the "obesogenic environment" of the modern society. The excessive focus on "low-fat" diets in recent decades has also significantly strengthened the reliance on sugar and other carbohydrates to improve taste and maintain caloric content leading to the exacerbating obesity epidemic.

Considering all these factors, obesity rates continue to rise due to ongoing negative trends in dietary and lifestyle habits such as technological advancements making life less “physical”.

More recent research has identified additional factors that contribute to the underlying cause of obesity. The human has up to 100 trillion symbiotic microbes that are living in the gut. They are referred as gut microbiota that are relying on food residues which are not digested by the body itself. This microbiome plays a crucial role in metabolism, immune function, and inflammatory disorders including obesity. Colonization begins at birth with vaginally delivered babies generally having a more

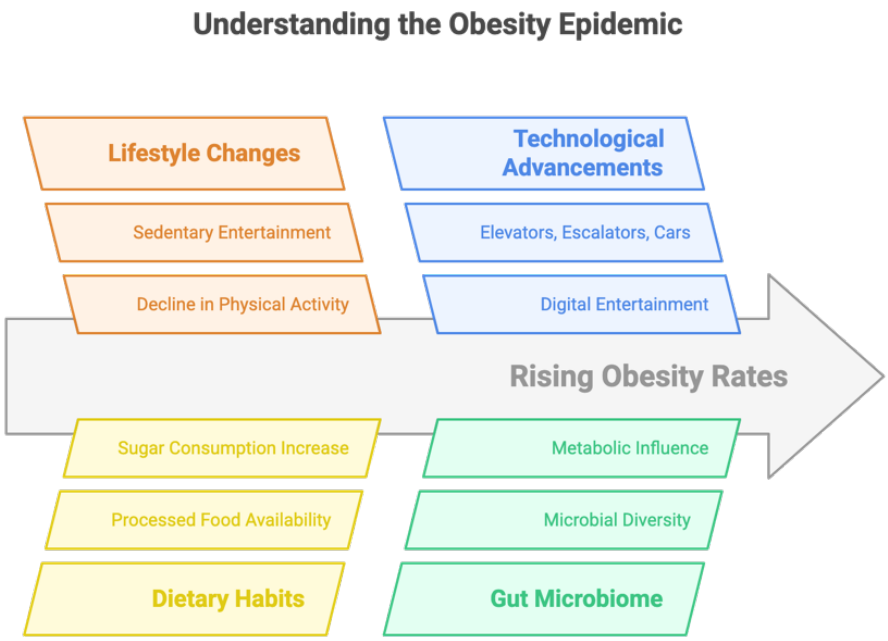

Figure 3 Understanding the Obesity Epidemic

diverse microbiome than babies delivered by C-Section. Factors like genetics, diet, and antibiotic use further shape gut bacteria. The gut microbiota plays a significant role in metabolic health by influencing nutrient absorption, fat storage, inflammation, and insulin resistance. Therefore, a high-fat diet may impair gut barrier function, which promotes systemic inflammation and metabolic dysregulation. Key bacterial phyla notably Firmicutes and Bacteroidetes dominate the gut and have been linked to obesity. A higher Firmicutes/Bacteroidetes ratio has been observed in some obese individuals and animal models, though findings remain inconsistent across populations.

Beyond phylum-level changes, species such as Akkermansia muciniphila and Christensenellaceae are associated with improved metabolic profiles. Whereas Lactobacillus and Bifidobacterium show species-specific effects—some strains correlating with leanness and others with weight gain. Gut microbiota also affects host metabolism via microbial metabolites including short-chain fatty acids and neuromodulators that regulate appetite and energy homeostasis through the gut-brain axis.
Experimental studies have shown that gut bacteria can influence fat storage mechanisms by modulating proteins like lipoprotein lipase (LPL) and its inhibitors (e.g., Fiaf and ANGPTL4), affecting hepatic lipid metabolism and adipocyte fat uptake.
Importantly, bariatric procedures such as gastric bypass and sleeve gastrectomy have been shown to induce lasting shifts in gut microbiota composition, including increased microbial diversity and enrichment of metabolically favourable species like Akkermansia muciniphila. These microbial changes may partially explain the observed improvements in glucose metabolism and weight loss outcomes following surgery and could be relevant for understanding mechanisms underlying gastric plication as well (11)(12)(13).

Ultimately, the least invasive approach for treating obesity remains within lifestyle changes and management including nutritional therapy, physical activity, and various intermittent fasting methods. Useful dietary strategies could include certain low-fat diets and high-quality ketogenic diets. However, sticking to these dietary changes remains a major challenge making intensive support and resources essential for patients undergoing lifestyle modifications. Physical activity provides benefits beyond weight loss. It positively impacts body composition and reduces risks for many diseases. Patients should be encouraged to follow an exercise regimen that aligns with their physical abilities. Additionally, multiple intermittent fasting approaches proved to be significantly effective in weight loss and metabolic health improvement (14).
If lifestyle modifications as mentioned above are still ineffective, surgical interventions remain an option. The American Society for Metabolic and Bariatric Surgery estimates that around 24 million people in the United States have severe obesity (BMI over 40 kg/m²). As a result, the demand for bariatric surgeries is expected to rise significantly over time (2).

4.4. Bariatric surgery

Bariatric surgery has been practiced since the 1950s with the first procedure, a jejunoileal bypass, performed by Dr. Kremen in 1954. Today three main types of bariatric surgery are commonly used to treat obesity. Additionally, advancements in laparoscopy and robotic surgery have significantly improved surgical outcomes. The most commonly performed surgeries are laparoscopic/ robotic

sleeve gastrectomy, laparoscopic/ robotic Roux-en-Y gastric bypass and laparoscopic/ robotic Gastric banding (2).

In recent years, the indications for metabolic and bariatric surgery (MBS) have been significantly broadened. According to the joint 2022 ASMBS and IFSO guidelines, individuals with a BMI ≥35 kg/m² are now suitable for surgery regardless of the presence of obesity-related comorbidities. Furthermore, MBS should be considered in patients with a BMI between 30–34.9 kg/m² if lifestyle and pharmacological interventions have failed and there is evidence of metabolic disease. These developments indicate a shift from relying solely on BMI thresholds to a more personalized evaluation of risks and benefits. For Asian populations, the BMI cut-offs are adjusted downward as obesity-related complications can occur at lower BMI values due to a higher percentage of visceral adiposity.

In addition to updated BMI criteria, the guidelines recognize obesity as a chronic, progressive disease requiring long-term management strategies. Metabolic and bariatric surgery (MBS) is not only effective for achieving significant and lasting weight loss but also offers superior outcomes in managing metabolic diseases and reducing mortality compared to non-surgical treatments. The adjusted criteria have also evolved to support surgical intervention in paediatric and geriatric individuals. In children and adolescents, surgical intervention may be considered when BMI exceeds 120% of the 95th percentile in the presence of comorbidities. In older adults, chronological age is no longer a strict contraindication. Instead, the surgical risk should be evaluated based on functional status and frailty. Moreover, the concept of revisional surgery is gaining acceptance as part of a long-term obesity care model, acknowledging the relapsing nature of the disease and the need for ongoing therapeutic adjustments (15).

Therefore, metabolic and bariatric surgery has evolved into a multifaceted therapeutic approach. It is not only aiming at weight reduction but also at the resolution or improvement of metabolic comorbidities such as type 2 diabetes, dyslipidaemia and hypertension. This broader understanding has reframed bariatric surgery as metabolic, rather than viewing it as a distinct or transitional concept.

Historically, six primary procedures have shaped the bariatric surgery. Jejunoileal bypass (JIB), Roux-en-Y gastric bypass (RYGB), vertical banded gastroplasty (VBG), biliopancreatic diversion (BPD) with or without duodenal switch (DS), adjustable gastric banding (AGB) and sleeve gastrectomy (SG). Each of these techniques demonstrated varying degrees of efficacy in weight loss and metabolic improvement. Yet all have also faced criticism due to long-term complications, technical limitations, or patient intolerance. Over time certain operations such as the JIB and VBG were largely abandoned, while others like SG have seen rapid adoption, despite concerns about issues such as staple line leaks and weight regain.

Beyond anatomical restriction and malabsorption which formed the classical explanatory model current understanding emphasizes the neurohormonal mechanisms of action. Bariatric procedures influence the secretion and regulation of several key hormones including GLP-1, peptide YY, leptin, ghrelin, and GIP. These hormones collectively regulate satiety, appetite, insulin secretion, and energy homeostasis. Additionally, the neural pathways especially afferent vagal and sympathetic fibers play a critical role in mediating appetite and metabolic function through central and peripheral feedback loops.

Chronic inflammation is now recognized as a central component of obesity and its associated metabolic syndrome. Excess adiposities particularly with leptin resistance and ectopic fat storage promotes a proinflammatory state, contributing to insulin resistance and endothelial dysfunction. Metabolic surgery appears to mitigate this inflammatory process leading to improved glycaemic control and metabolic outcomes independent of weight loss alone.

Energy metabolism also undergoes significant changes postoperatively. Alterations in total energy expenditure, including reductions in basal metabolic rate and adaptive thermogenesis, are observed. Though these responses are not yet fully understood and vary by individual metabolic phenotype.

In summary, bariatric surgery must be viewed as a dynamic and system-wide metabolic intervention. It offers a window into the mechanisms underlying obesity and type 2 diabetes and serves not only as a clinical tool but also as a model for understanding the pathophysiology of metabolic disease. As surgical techniques continue to evolve, so too must the scientific framework underpinning them with increasing emphasis on hormonal, neurological, and inflammatory pathways (16).

Another emerging procedure that is less commonly used will be focussed on in this paper. Laparoscopic gastric plication (LGCP) is a restrictive technique that reduces the stomach capacity by infolding the greater curvature with sutures. Unlike the other bariatric procedures this technique allows the surgeon to perform the operation without cutting or removing any part of the stomach or implanting devices. Therefore, it could be more suitable for younger patients or individuals that prefer a procedure without resection or foreign body. Furthermore, without staple lines it is expected to minimize the risk of leakage compared to LSG. LGCP appears to provide genuine vertical gastric restriction without the obstruction associated with AGB, where the band creates a horizontal gastric division (17).

However, LGP has not become widely accepted in the U.S. and is still regarded as experimental by the ASMBS (18).

It is still considered to be a relatively new surgical procedure. Gastric Plication was proposed by Wilkinson and Peloso back in 1981 and later introduced in 2006 by Dr. Talebpour in Iran. Initially, it was meant to be a procedure which mimics the already well-established results of Laparoscopic

Sleeve Gastrectomy. He began performing his surgeries in private hospitals in Iran having the factor of scarcity in equipment and resources. Therefore, he tried to establish a method without costly materials such as laparoscopic staplers. LGCP, which Dr. Talebpour originally referred to as "Total Vertical Gastric Plication" was first tested in animal models, particularly in sheeps before being performed on volunteer patients. The first results were published in 2006, followed by a 2007 study presenting a series of 100 consecutive patients, which helped establish LGCP as a recognized procedure in the treatment of morbid obesity. However, its application remains a topic of ongoing debate. The procedure offers several potential advantages over LSG, primarily due to the absence of anastomotic lines eliminating the risk of staple line leaks as already mentioned above. Despite these benefits, LGCP has been the subject of relatively few publications resulting in limited data on both outcomes and complication rates especially in regard to long-term results. In contrast, LSG offers a larger availability in studies as it is widely investigated in clinical research. This scarcity of literature has led to scepticism within the international surgical community and prompted the American Society for Metabolic and Bariatric Surgery to issue a statement in March 2011 with specific recommendations:
Gastric plication is currently still considered an investigational procedure. It should only be performed within a structured study protocol under the supervision of an independent third party such as a local or regional ethics committee, institutional review board, or data monitoring and safety board to ensure ongoing assessment of patient safety and the monitoring of adverse events and outcomes.
Additionally, reporting both short- and long-term safety and efficacy results in medical literature is highly recommended, and relevant data should be included in a program's centre of database. Furthermore, any marketing or advertisement related to this procedure must explicitly state that it is still an investigational procedure (19).

5. Objective

The aim of this study is to review current publications on LGCP especially long-term results of gastric plications (≥3 years) establishing effectiveness in terms of weight loss outcomes, safety (rates of complications, re-operations, long term adverse effects), durability such as weight regain and patient satisfaction including quality of life outcomes. Moreover, this study aimed to create a framework for comparison with more common bariatric surgeries such as RYGM or LSG. As it is a relatively new procedure most of the existing literature is discussing short-term results which is why this paper focuses on the long-term results.

6. Methodology

A comprehensive online literature research was conducted in PubMed, Cochrane library and google scholar using key words such as “obesity”, “gastric plication”, bariatric surgery” and “long term results”. 104 articles were sourced from the databases and screened for their abstracts and titles. Duplicates were removed and irrelevant search topics were excluded.

In the next step, the remaining 25 full texts were reviewed to determine whether the studies met the specific criteria for inclusion. Studies were included when reporting ≥ 3-year outcomes of gastric plication. Retrospective and prospective studies were focussed on. The studies had to include at least one relevant outcome – in terms of weight loss including either %EWL, %TWL or %EBMIL, patient satisfaction, complications or remission rates of obesity-related comorbidities. Laparoscopic gastric plication (LGGCP) as a primary bariatric procedure had to be reported.

The article had been chosen from the timeframe from 2010 – 2024. The search was limited to articles that are published in English. Studies were excluded with patients having ≤ 3-year follow-ups, publication of case reports, abstracts only, letters and comments. Studies with duplicate populations or incomplete outcome data were excluded as well.

A total of 7 articles were identified with all the inclusion criteria and relevant data.

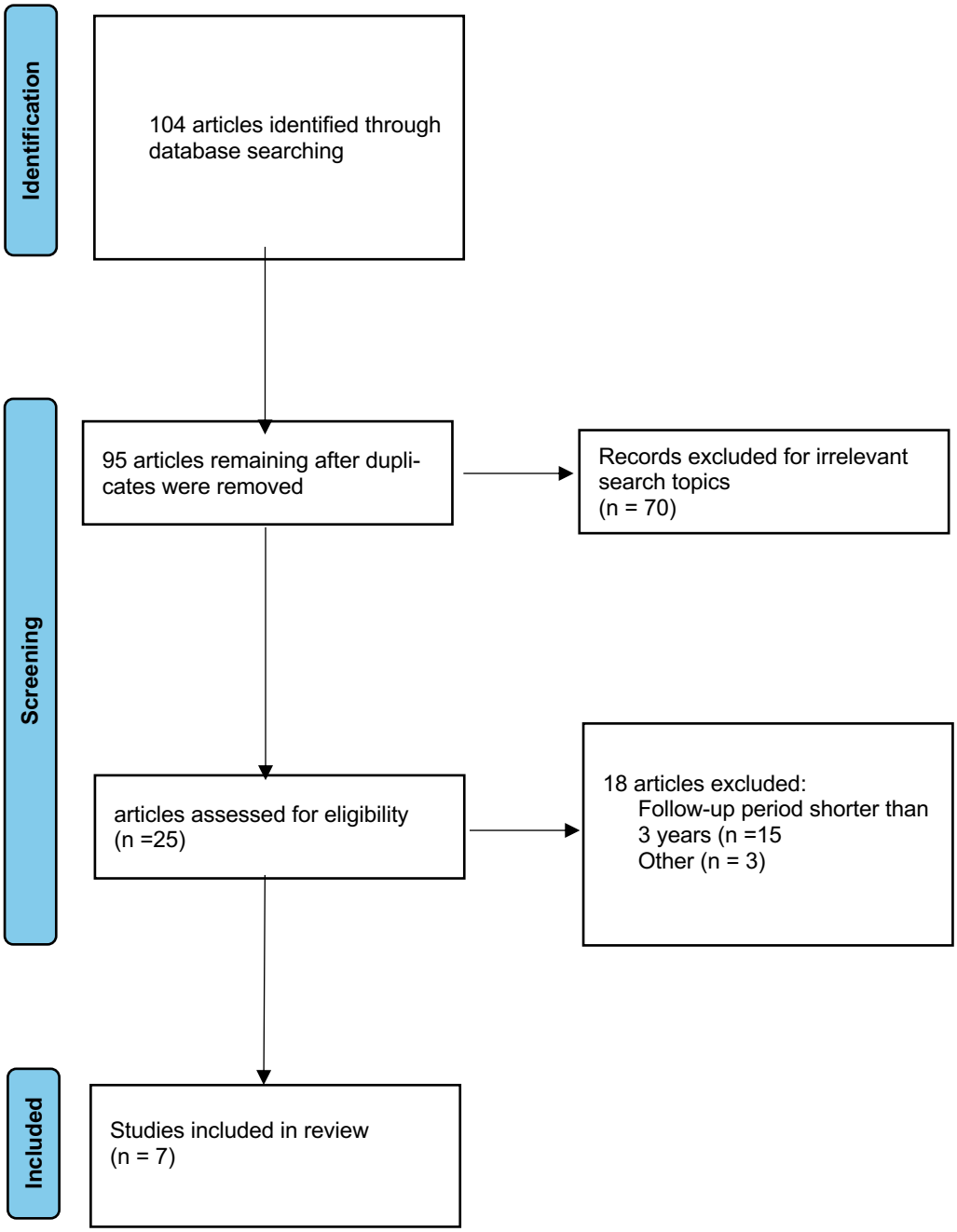

Figure 4 Study PRISMA flow chart

7. Results

7.1. Literature review

In total 7 Studies (4 retrospective, 2 prospective case series and 1 Cohort Study), involving 1405 patients who underwent gastric plication, were included in the final analysis. Important characteristics were demonstrated in table 1 and 2. Among the patients 78.5% were women and 21.5 % men. The mean age of the patients at the time of surgery was 38 years. The mean preoperative BMI was 39,82 kg/m2.

Authors	*Patients (n)*	*Mean preoperative BMI (kg/m2)*	*Months of follow up*	*Method*	*Patients who reached ≥5 year follow-up point (%)*
Lien-Cheng Tsao et al. 2022(20)	49	33.3	36	Retrospective file review	-
R. Gudaityte et al. 2018(21)	61	46.3	36	Prospective noncompara-tive case series	-
K. Doležalova-Kormanova et al. 2017(22)	244	41.4	60	Cohort study	86.9
Ji-Hyeon Park et al. 2022(23)	75	34.5	81.75	Retrospective study	-
Mohammad Tale-bpour et al. 2012(24)	800	42.1	Mean 60	Prospective case series	16.75
Khosrow Najjari et al. 2023(25)	94	40.43	60	Retrospective cohort	-
Mohamed Abdel-gawad et al. 2022(26)	88	40.72	72	Retrospective analysis	68.18

Table 1 Characteristics of the reviewed studies

The duration of follow up varied from 1 to 12 years. Two studies reported 3-year results, two studies reported 5-year results, one study showed 6-year results, another study presented up to 7-year results and another study reported up to 12-year results.

All studies showed the results in regard to body weight changes with either EWL%, TWL% or EBMIL% seen in table 3. 5 Studies relied on EWL% while only the study R. Gudaityte et al. 2018 used EBMIL% as single marker. The Ji-Hyeon Park et al. 2022 study reported only TWL%.

Author	*Mean Age in years*	*Female*	*Male*	*Mean Preoperative BMI*
Lien-Cheng Tsao et al. 2022	34	36	13	33.3
R. Gudaityte et al. 2018	47.4	13	48	46.3
K. Doležalova-Kormanova et al. 2017	45.8	173	39	41.4
Ji-Hyeon Park et al. 2022	34.35	62	7	34.5
Mohammad Talebpour et al. 2012	27.5	650	150	42.1
Khosrow Najjari et al. 2023	35.63	73	21	40.43
Mohamed Abdelgawad et al. 2022	41.3	49	11	40.72

Table 2 Patient Characteristics

7.2. Weight loss

The study by Talebpour et al. 2012 demonstrated initial effectiveness with an EWL% of 67% at one year, which was largely maintained at three years (EWL of 66%) followed by a noticeable decline at five years (55%).

In contrast, Khosrow Naijari et al. 2023 reported the highest initial outcomes among the analysed studies with an EWL% and EBMIL% of 84.41% and a TWL% of 30.56 after one year. However, this significant short-term success was not fully sustained leading to a decline of 57.8% EWL%, 57.65% EBMIL% at the five-year follow-up.

K. Doležalova-Kormanova et al. 2017 provided detailed outcomes across all three parameters and intervals revealing highest weight loss at three years follow up (EWL% of 55.6%, TWL% of 23.4%, and EBMIL% of 60.2%). Subsequently, a slight decline was still observed by five years indicating moderate long-term stability (EWL% of 52.6, TWL% of 22.1, EBMIL% of 56.8).

The results from Lien-Cheng Tsao et al. 2022 and Mohamed Abdelgawad et al. 2022 also indicated a declining trend in weight loss efficacy over time, although the way of reporting was less comprehensive. Notably, some studies including those by Ji-Hyeon Park et al. 2022 and R. Gudaityte et al. 2018 reported limited data, restricting comprehensive comparison and interpretation across the different time intervals and weight loss parameters.

Mean EWL% after one year across the studies was 60.1% with values ranging from 42.2 to 84.41%. The mean TWL% at that time was 24.79%, based on data from Tsao et al. (17.2%), Doležalova-

Kormanova et al. (19.4%), Najjari et al. (30.56%), and Ji-Hyeon Park et al. (29.9%). The mean EBMIL% after one year is 60.77% ranging from 47.2% up to 84.41%.

At 3 years the mean %EWL is 52.53% reporting from three articles: 36% (Tsao et al. 2022), 55.6% (Doležalova-Kormanova et al. 2017), and 66% (Talebpour et al. 2012). Mean 3-year TWL% which was only reported in two studies are 18.85% with values of 14.3% (Lien-Cheng Tsao et al. 2022) and 23.4% (K. Doležalova-Kormanova et al. 2017). EBMIL% was reported in two studies as well, averaging 51.05% based on 41.9% (R. Gudaityte et al. 2018) and 60.2% (K. Doležalova-Kormanova et al. 2017).

After 5 years mean EWL% at this stage was 54.58%. Mean %TWL is 19.44% and mean EBMIL after 5 years is 57.23%.

Author	*EWL%*			*TWL%*			*EBMIL%*		
	1yr	3yr	5yr	1yr	3yr	5yr	1yr	3 yr	5 yr
Lien-Cheng Tsao et al. 2022	42.2	36	-	17.2	14.3	-	-	-	-
R. Gudaityte et al. 2018	-	-	-	-	-	-	47.2	41.9	-
K. Doležalova-Kormanova et al. 2017	46.8	55.6	52.6	19.4	23.4	22.1	50.7	60.2	56.8
Ji-Hyeon Park et al. 2022	-	-	-	29.9	-	-	-	-	-
Mohammad Talebpour et al. 2012	67	66	55	-	-	-	-	-	-
Khosrow Najjari et al. 2023	84.41	-	57.80	30.56	-	21.14	84.41	-	57.65
Mohamed Abdelgawad et al. 2022	-	-	38.93	-	-	15.09	-	-	-

Table 3 Percentage of EWL%, TWL% and EBMIL% at different time intervals

7.3. Comorbidities

In regard to preoperative comorbidities seen in table 4 and figure 5 fatty liver, arterial hypertension and type 2 diabetes mellitus appear prominently across the studies. Dyslipidaemia follows closely after. A few cases of obstructive sleep apnoea such as degenerative joint disease and GERD are reported as well.

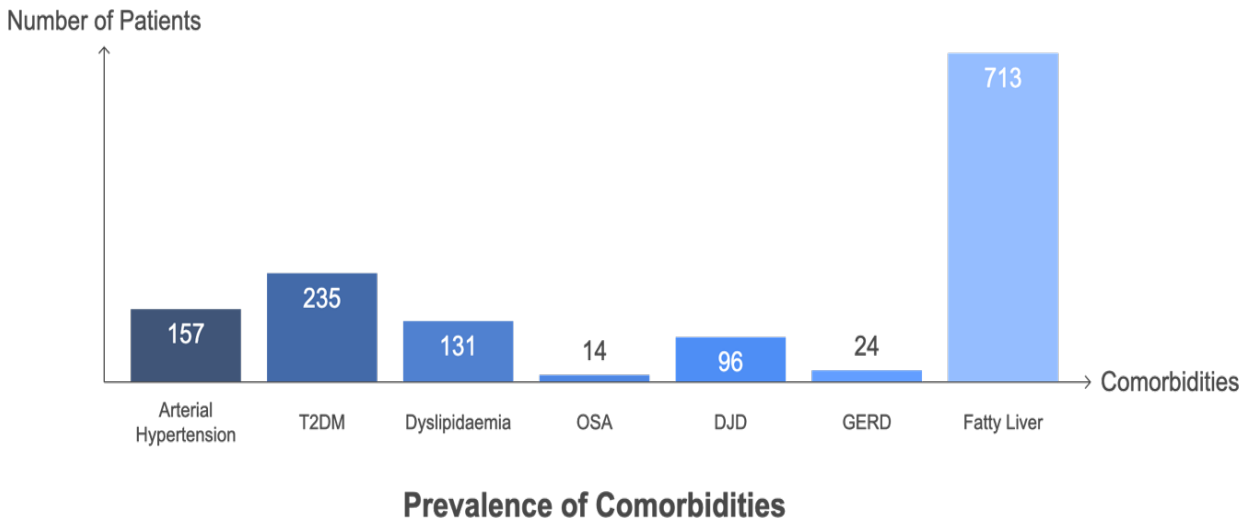

Figure 5 Prevalence of comorbidities

Notably, the study by Doležalova-Kormanova et al. 2017 shows very high rates of both hypertension in 98 patients and T2DM in 58 patients as well as dyslipidaemia in 38 patients. Similarly, the research by Talebpour et al. 2012 highlights total of 88 patients with T2DM representing 11% of total comorbidities. There are notably high numbers of fatty liver with 682 patients being 85% of total comorbidities reported. Furthermore, knee and low back pain were reported with 40 patients (5%) which are categorized as degenerative joint disease in this paper. Sleep apnoea was reported in 4 patients (0.5%) and dyslipidaemia in 32 patients (4%).

Author	*AHT*	*T2DM*	*Dyslipidaemia*	*OSA*	*DJD*	*GERD*	*FL*
Lien-Cheng Tsao et al. 2022	19	6	8	5	5	-	10
R. Gudaityte et al. 2018	47	19	-	-	-	24	-
K. Doležalova-Kormanova et al. 2017	98	58	38	-	-	-	-
Ji-Hyeon Park et al. 2022	4	2	9	2	-	-	9
Mohammad Talebpour et al. 2012	8	88	32	4	40	-	682
Khosrow Najjari et al. 2023	17	39	45	-	51	-	-
Mohamed Abdelgawad et al. 2022	9	21	5	6	5	-	-
Total	157	235	131	14	96	24	713

Table 4 Preoperative comorbidities

The Khosrow Najjari et al. 2023 study also reported elevated numbers especially in dyslipidaemia (45 patients), T2DM (39 patients), and degenerative joint disease (51 patients).
Obstructive sleep apnoea is relatively less frequently reported across all the studies in comparison to other comorbidities, but it's still present in studies by Ji-Hyeon Park et al. 2022 and Abdelgawad et al. 2022. GERD was specifically reported by Gudaityte et al. 2018 in 24 patients.
Reviewing all the articles, a total of 157 patients were reported with AHT, 235 cases of T2DM were reported, 131 individuals had dyslipidaemia, 14 were diagnosed with OSA, 96 had DJD, 24 suffered from GERD and 713 cases reported having FL coming mainly from Mohammad Talebpour et al. 2012.

7.4. Remission and improvement

In addition to weight loss, the included studies reported remission rates concerning obesity - associated comorbidities.
Lien-Cheng Tsao et al. 2022 had out of the 5 LGCP patients with T2DM evaluated postoperatively 4 (80%) achieved remission. From the 8 patients initially diagnosed with dyslipidaemia 7 (87.5%) achieved remission. Of the 6 patients initially suffering from hypertension 4 patients (66.7%) reached remission.
At the three-year follow-up, significant remission and improvement of the comorbidities were observed in R. Gudaityte et al. 2018. Among patients initially diagnosed with hypertension, remission occurred in 18 patients (38.3%), while an additional 14 patients (29.8%) experienced an improvement of hypertension. Regarding T2DM, three patients (16.7%) had complete remission (HbA1c < 6% and FPG < 5.6 mmol/l without pharmalogical therapy). Two patients (11.1%) were observed with partial remission (HbA1c 6.9 – 6.4 % and FPG 5.6 – 6.9 mmol/l without pharmacological therapy). 8 patients (42.1%) were reported with improvement, three patients (22.2%) with no changes and one case (5.5%) with conditions being worse than before surgery.
GERD prevalence was reduced postoperatively from 46% to 25% (from 24 patients 6 resolved). Nevertheless, new-onset GERD developed in 11 patients (39.3% of patients who were initially asymptomatic preoperatively, highlighting a postoperative complication associated with LGGCP.

The study Doležalova-Kormanova et al. 2017 reported hypertension in 98 patients (46.2%), T2DM in 58 patients (27.4%), dyslipidaemia in 38 patients (17.9%) and other various conditions that are not mentioned in table 3 and not accurately described in the paper such as hypothyroidism, asthma, sleep apnoea, depression, and arthropathy in 20 patients (9.4%). Postoperatively, significant improvements in T2DM were observed. At the 2-year follow-up, 89.7% (52 out of 58 patients) experienced substantial improvement in diabetes management defined by lowering in fasting glucose, HbA1c levels or

diabetes medication requirements. Six cases (10.3%) demonstrated no significant changes. By the 5-year follow-up the improvement was still notable but had decreased from 89.7% to 65.5% (38 out of 58 patients) showing a considerable yet reduced long-term effectiveness. Although the study clearly documented the prevalence of hypertension, dyslipidaemia and other comorbidities before surgery explicit remission or improvement rates for these were not described in the article. Instead, the study mainly focused on weight outcomes and diabetes resolution as primary clinical endpoints.

In the study conducted by Ji-Hyeon Park et al. 2022 various comorbidities were observed among the patients who underwent LGGCP and later required revision surgery due to weight regain. Therefore, this study was structured with a non – revision group (n = 56) and revision group (n =13). In table 3 only the non-revision group (n=56) was involved as the revision group mainly received sleeve gastrectomy (12/13 patients). Therefore, it is not significant for this review.

In the non-revision patient group of the study T2DM was present in two patients, hypertension in four patients, dyslipidaemia in 9 patients, NAFLD in 14 patients and obstructive sleep apnoea syndrome in 2 patients. At the long-term follow-up after 92.5 months good remission rates were noted across nearly all comorbidities. T2DM, dyslipidaemia, NAFLD and obstructive sleep apnoea were completely resolved in all previously affected patients demonstrating a 100% remission rate for these conditions. Hypertension showed a moderate remission outcome with 2 of the initial 4 hypertensive patients achieving remission.

Author	*AHT*	*T2DM*	*Dyslipidaemia*	*OSA*	*DJD*	*GERD*	*FL*
Lien-Cheng Tsao et al. 2022	4	4	7	-	-	-	-
R. Gudaityte et al. 2018	18	5	-	-	-	6	-
K. Doležalova-Kormanova et al. 2017	-	35	-	-	-	-	-
Ji-Hyeon Park et al. 2022	2	2	9	2	-	-	14
*Mohammad Talebpour et al. 2012**	6	84	22	4	40	-	291
Khosrow Najjari et al. 2023	17	30	24	-	18	-	-
Mohamed Abdelgawad et al. 2022	6	14	-	-	-	-	-
Total	53	177	62	6	58	6	305

*Table 5 Total numbers of remission of comorbidities after surgery; (*after 1 year)*

In the revision group before the second surgery the 13 patients presented with several comorbidities such as T2DM in two patients, hypertension in two patients, dyslipidaemia in two patients and notably non-alcoholic fatty liver disease (NAFLD) in nine patients. In addition, there was one patient with osteoarthritis, two patients with asthma, four patients with GERD, four patients with dyspepsia and one patient with chronic relapsing melena.

One year after revision surgery which were primarily conducted with sleeve gastrectomy (12/13 patients) outcomes were highly favourable. Complete remission was achieved for both patients with diabetes mellitus. Of the two patients initially suffering from hypertension one experienced remission. Similarly, dyslipidaemia resolved completely in one of two affected patients. Notably, a high remission rate was observed for non-alcoholic fatty liver disease with eight out of nine patients experiencing resolution. The patient diagnosed with osteoarthritis reported full symptom remission as well. One of the two patients with asthma also achieved remission. GERD showed significant improvement with three out of four affected patients no longer requiring treatment, though one patient continued medication postoperatively. Dyspepsia symptoms and chronic relapsing melena resolved completely in all affected patients.

In the 12-year study by Talebpour et al. 2012 fatty liver disease was highly prevalent before surgery observed in 682 patients (85%) categorized by severity:

- Grade 1 (G1): 421 cases (52%)
- Grade 2 (G2): 154 cases (19%)
- Grade 3 (G3): 107 cases (13%)

Other comorbidities included T2DM in 88 patients (11%), hypertension in 8 patients (1%), hypertriglyceridemia in 32 patients (4%), knee or low back pain in 40 patients (5%), and sleep apnoea in 4 patients (0.5%).
At one-year follow-up significant remission or improvement in these comorbidities were reported. For fatty liver disease substantial remission occurred with Grade 1 disease fully resolving in 211 of the 242 evaluated patients (87%). For Grade 2 fatty liver, 45 out of 91 evaluated patients (49%) fully recovered with 27 patients improving to Grade 1. Among Grade 3 cases 35 out of 102 evaluated patients (34%) experienced complete resolution with an additional 48 patients improving to less severe grades.
T2DM showed substantial remission as well with 62 out of 88 patients (70%) achieving remission at six months. After one year the number increased to 84 out of 88 patients (95%). Hypertension

remission was observed in half of the affected patients at six months (4 out of 8 patients) which improved to 6 patients (80%) after one year. Hypertriglyceridemia resolved in 13 of the initially affected 32 patients (40%) at six months and increased to 22 patients (70%) after one year. Musculoskeletal issues such as knee or low back pain showed significant relief in 32 of 40 patients (80%). They experienced remission at six months and complete remission was reported at one year for all affected patients. Sleep apnoea resolved completely in all 4 affected patients (100%) both at six-month and one-year follow-ups. The improvements or remission of comorbidities were only followed at after 6 months and 1 year-follow ups. Therefore, long term data in that regard was not given.

In Khosrow Najjari et al. 2023 the patients presented with preoperative comorbidities such as hyperlipidaemia in 45 patients (47.9%), joint or lower back pain in 51 patients (54.3%), T2DM in 39 patients (41.5%), hypertension in 17 patients (18.1%) and hypothyroidism in 17 patients (18.1%). After surgery in an over 5-year postoperative period numerous improvements or remission of these comorbidities were reported. At the five-year follow-up hypertension showed a remission rate of 100% with all 17 initially affected patients experiencing complete remission or substantial improvement. T2DM showed a strong remission rate of 76.9% resulting in major improvements in 30 patients. Hyperlipidaemia also improved in 24 cases with 54.5% of the affected patients. Hypothyroidism showed positive outcomes as well with 88.2% of the patients experiencing improved thyroid function tests. 15 Patients had remission. Finally, joint or low back pain had the lowest remission rate with 35.3% of the patients reporting symptom relief with 18 patients experiencing resolution.

In the study conducted by Abdelgawad et al. 2022 the obesity-associated comorbidities were assessed over a 6-year postoperative period in 60 patients. Preoperatively, the patients exhibited multiple comorbidities, with T2DM being the most prevalent affecting 21 patients (35%). Hypertension was observed in 9 patients (15%), obstructive sleep apnoea was documented in 6 patients (10%), hyperlipidaemia was present in 5 patients (8.3%), and osteoarthritis similarly affected 5 patients (8.3%). Additionally, gallstones were noted in 4 patients (6.7%) which simultaneously received laparoscopic cholecystectomy during LGP surgery.

Postoperative outcomes demonstrated significant, but in time declining remission and improvement rates for comorbidities. For patients with T2DM a substantial improvement was initially observed in 18 cases with 85.7% of the initial diabetic patients experiencing improvement at the 2-year follow-up. However, this rate declined by the 6-year follow-up with improvement observed in 14 patients (66.6%). Hypertension showed similar course with 77.7% improvement at the 2-year follow-up decreasing to 66.6% at 6 years. The study did not report any date in regard to the remission rates for obstructive sleep apnoea, hyperlipidaemia and osteoarthritis.

Summing up the total results of existing comorbidities before surgery from all the gathered articles 157 patients had arterial hypertension, 235 patients reported to have T2DM, 131 patients with Dyslipidaemia, 14 patients with obstructive sleep apnoea, 96 patients with degenerative joint disease, 24 individuals with GERD and 713 patients with fatty liver disease (mainly from Talebpour et al 2012).

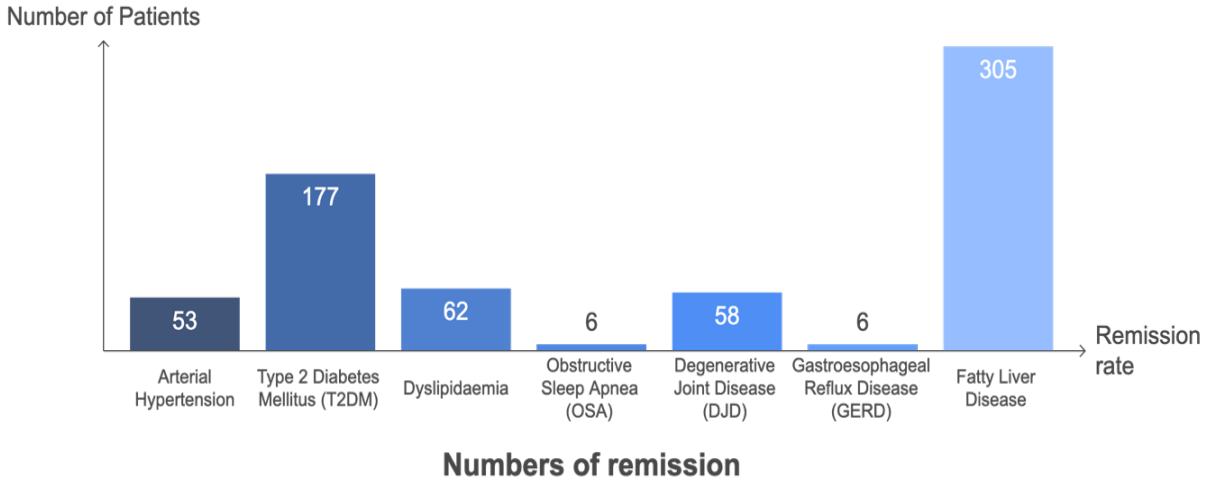

Figure 6 Numbers of remission

Remissions and improvements were reported in 53 patients that had arterial hypertension. 177 patients that had T2DM, 62 patients experiencing improvement or remission with Dyslipidaemia, 6 patients with obstructive sleep apnoea, 58 patients that were relieved from degenerative joint disease, 6 cases from GERD and 305 patients experienced remission in regard to their fatty liver disease.

7.5. Complications

As every surgical procedure laparoscopic gastric plication is also associated with a range of complications.

R. Gudaityte et al. 2018 reported an overall complication rate of 4.9% (3 patients), with two patients having obstruction. One was having it in the proximal part of the stomach and the other patient had it at the angle of the stomach due to too tight plication. The second one needed reoperation and the other one received successful conservative treatment. Another patient had bleeding from the gastroepiploic artery, which needed re-laparoscopy. So, in total this article included two cases of reoperation (3.3%). Additionally, 31 patients (50.8%) had gastroscopy data after 3 years postoperatively

where they found partial disruption of plication fold in 10 cases (32.3%) and complete disruption in 4 cases (12.9%).

In the large 12-year study of Mohammad Talebpour et al. 2012 they reported an overall reoperation rate of 1% (8 patients). Reasons were due to micro-perforations (3 cases), postoperative obstructions (3 cases) because of displacement of the released fundus outside the suture line and extra-expansion. In another case unusual adhesions between fundus and traumatized liver caused vomiting and discomfort and one case was described with intracapsular abscess. They also reported that reoperation was additionally done in 32 patients due to regain, failure (6 cases) or other reasons such as appendicitis (3 cases) and gallstone (12 cases. They showed an unchanged suture line and little expansion of the stomach. Late complications after 1 month were not reported. Weight regains after 12 years reached 31%.

Mohamed Abdelgawad et al. 2022 observed early post operative complications like nausea, vomiting or epigastric pain in 5 cases (8.3%). New-onset GERD was reported in 18.3%, 15% and 10% of cases at 3-, 6- and 12-month follow-up visits but they declined in the following years. After endoscopic evaluation of 50 patients after 6 years they observed erosive esophagitis in four patients. Three of them had grade A reflux esophagitis while the other one was diagnosed with grade B reflux esophagitis.
One case was reported with a major complication and needed emergency reoperation because of leakage in the plicated gastric fundus from the proximal one-third. It was managed by conversion into LSG and an undoing of the plication.
A total reoperation rate of 23.3% (14 patients) was reported mostly elective (13 patients; 21.6%) driven by significant weight regain and GERD (58.3%). The study identified disrupted plication folds, increased hunger sensation, and non-compliance with exercise as significant predictors for weight regain.

Lien – Cheng Tsao et al. 2022 compared LGGCP with laparoscopic sleeve gastrectomy (LSG) in 280 patients reporting a significantly higher reoperation rate in the LGGCP group compared to LSG (14.3% vs. 1.7%). Reasons for reoperation in 11 patients were because of weight regain and unsatisfying weight loss. The LGCP (n =49) group reported no complications.

Khosrow Najjari et al. 2023 documented a complication rate of 17% (16 patients). 2.1% (2 cases) experienced abdominal pain and gastrointestinal bleeding, 14 patients reported prolonged nausea and

vomiting. Although none of them required reoperation. They were all treated conservatively. Weight regains was observed in 46.3% of patients after five years.

In K. Doležalova-Kormanova et al. 2017 they reported a complication rate of 4.9% (12 patients) consisting of 1.6% emergency reoperations (4 patients) and 3.3% elective procedures (8 patients). It included one conversion intraoperatively from laparoscopy to laparotomy. Nine cases needed hospital readmission but no reoperation. 6 of them received gastroscopy and were diagnosed with gastric mucosal irritations or lesions seen in the lower third of the plication ridge. Moreover, postoperative nausea and vomiting were reported in 86 patients representing 27.8%. Major complications in one patient that received emergency surgery had gastric diverticulum in the proximal third of the gastric fundus. He experienced vomiting for more than one week and postprandial epigastric pain. A stomach wall diverticulum which was approximately 2 x 3 cm was found between invaginating suture bites. Afterwards, it was reinvaginated and the greater curvature was reconstructed with 2 - 0 Prolene sutures.
After the 5-year follow up, four elective surgeries were done because of stomach dilation and/ or due to suture-line disruption causing premature weight loss or a reduced feeling of hunger after eating. Three of them received replication surgically by adding 1 – 2 invaginating rows with Prolene 2/0 sutures.
Mean weight regain was 9.2% ranging from 0.3 – 23 %. They reported three emergency reoperations in the first 18 months, four of them elected for reoperation.

Lastly, Ji – Gyeon Park et al. 2022 documented a revision surgery rate of 17.3% (13 patients) due to significant weight regain during a long-term follow-up exceeding five years. Additionally, postoperative complications included GERD (4/13 patients, 30.8%) and dyspepsia (4/13, 30.8%) and chronic relapsing melena (1/13, 7.7%). Additionally, two patients (2/13, 15.4%) experienced immediate postoperative complications.

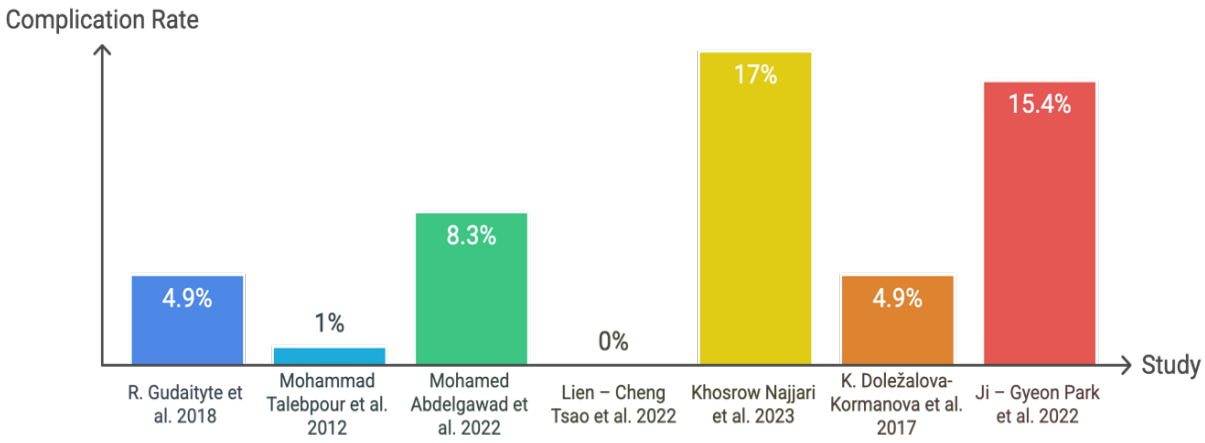

Figure 7 Complication rate after gastric plication

In summary LGGCP demonstrates variable long-term effectiveness with complication rates ranging from as low as 0% up to 23.3% for reoperations depending on follow-up duration and surgical technique. Commonly observed long-term complications include substantial weight regain, GERD, dyspepsia, and occasionally serious gastrointestinal symptoms requiring revision surgeries.

8. Discussion

8.1. Weight loss

Based on the collected data from all the studies on laparoscopic gastric plication the effectiveness of this bariatric procedure in achieving significant and sustained weight loss appears promising. Variability can still be noticed.

Excess weight loss as a primary outcome is frequently utilized to assess the effectiveness of bariatric surgery. Khosrow Najjari et al. 2023 reported the highest EWL% after one year at 84.41% which remained notably high at 57.80% even in long term follow up after five years. They included a sub – group analysis showing that patients with BMI > 30 after 60 months of follow up showed a higher rate of weight regain compared to the patients with < 40 BMI.

Similarly, Mohammad Talebpour et al. 2012 which is one of the largest cohorts over the longest follow-up showed initial EWL% of 67% after one year but then gradually declining to 66% after three years and stabilizing again at 55% after five years of follow-up. The dropout rate in this study presents a significant limitation in assessing the long-term effectiveness of laparoscopic gastric plication. While the authors report a 16.7% loss to long-term follow-up (134 out of 800 patients) the actual number of patients included in the excess weight loss percentage analysis declined much more.

After one year only 491 from the initial 800 patients remained indicating that nearly 40% of the initial cohort was not accounted for in the EWL% evaluation at the one-year follow-up date. After 5-year follow up only 134 cases were reported for EWL% showing a loss or dropout of 83.3%.
The study does not provide a clear explanation for this substantial reduction in sample size. This raises concerns about selection bias as it is unclear whether patients lost to follow-up had poorer weight loss outcomes or experienced complications. The exclusion of such a large proportion of patients from the EWL% calculations may overestimate the reported success rates by including only those who achieved favourable results while omitting those who may have struggled with inadequate weight loss or post-surgical issues.

A more detailed analysis of the reasons for dropout, including whether these patients required revision surgery, experienced complications, or failed to achieve satisfactory results would enhance the reliability of the findings.

K. Doležalova-Kormanova et al. 2017 demonstrated a moderate yet steady increase of EWL% from 46.8% at one year to 55.6% at three years and finally maintained at 52.6% at five years follow-up.
The study found that BMI was significantly reduced from 41.4 to 31.3 kg/m2 at 2 years and to 32.0 kg/m2 at 5 years representing good results. It was the only study out of them all that included %TWL, %EWL and EBMIL% across 1-, 3- and 5-years postoperative follow-ups suggesting that LGCP weight loss can substantial and long-lasting.

In comparison, Lien-Cheng Tsao et al. 2022 and Mohamed Abdelgawad et al. 2022 both presented lower EWL% at 42.2% and 36% after one and three years and 39.93% after five years.
Mohamed Abdelgawad et al. 2022 reported an average BMI drop from 40.72 to 33.75 kg/m² within the first year. This significant decline continued for two years reaching 32.11 kg/m². Between years 2 and 4, BMI remained relatively stable with no notable changes. However, from years 4 to 6 a moderate but significant increase was observed reaching 35.90 kg/m². This trend was more pronounced in patients who initially had a BMI over 40. During the follow-up period, 11 patients (18.3%) experienced inadequate weight loss. By the 6-year mark, 35 patients had regained weight, resulting in a weight regain rate of 58.3%.
At the 6-year follow-up, endoscopic evaluation was performed on 50 patients (83.3%) revealing a partially or completely disrupted plication fold in 40 cases (80%).

Total weight loss percentage varied similarly with Khosrow Najjari et al. 2023 reporting significant results of 30.56% at one year and maintaining effectiveness with a TWL% of 21.14% after five years. K. Doležalova-Kormanova et al. 2017 reported consistent results with 19% TWL at one year with

gradual improvement reaching 22.1% after five years suggesting stable long-term outcomes. Mohamed Abdelgawad et al. 2022 comparatively showed a lower TWL% outcome with only 15.09% after 5-year follow-up indicating the variability observed in the literature. Lien-Cheng Tsao et al. 2022 as well showed declining TWL% from 17.2% to 14.3% from 1 year to 3 years after surgery.

The excess BMI loss percentage also supports the positive outcomes mentioned earlier particularly shown by Khosrow Najjari et al. 2023 reporting remarkable results of 84.41% at one year and after 5 years still substantial results at 57.65%. Likewise, K. Doležalova-Kormanova et al. 2017 maintained a solid ground of over 50% EBMIL after one year, improving to >60% by three years and slightly decreasing to 56.8% after five years emphasizing the sustained effectiveness of gastric plication.

All in all, these results suggest that gastric plication offers significant and stable weight loss outcomes in the medium to long term. Nevertheless, considerable variability across the analysed studies exists. Differences in surgical technique, patient selection criteria, compliance to postoperative recommendations and follow-up rates likely contribute to these differences. Thus, while gastric plication can effectively cause substantial weight reduction, it remains crucial to maintain follow-up and patient adherence to lifestyle changes.

Weight regains following laparoscopic gastric plication has been documented across the studies with different rates depending on the length of follow-up and patient adherence to postoperative follow ups. Generally, significant weight regain was reported within 2 to 6 years postoperatively with some studies noting long-term weight regain up to 12 years. The primary causes include disruption of the plication fold and inadequate weight loss maintenance.

Gudaityte et al. 2018 reported a reoperation rate of 6.7% within 2–3 years because of weight regain or inadequate weight loss as the primary reasons. Similarly, Tsao et al. 2022 noted a higher reoperation rate for LGP (14.3%) compared to sleeve gastrectomy (1.7%) at 3 years again due to insufficient weight loss as a key factor. Park et al. 2022 found that 17.3% of patients required revision after approximately 5 years due to loss of restriction or near-complete fold dissolution.

Longer-term follow-ups further highlight the progressive nature of weight regain after LGP. Abdelgawad et al. 2022 documented a 58.3% regain rate at 6 years with disrupted plication folds, increased hunger sensations, and lack of adherence to an exercise regimen identified as key contributors. Najjari et al. 2023 reported a weight regain rate of 46.3% at 5 years while Doležalova-Kormanova et al. 2017 observed a mean regain of 9.2% (ranging from 0.3% to 23%) at the same time point with some cases requiring revision due to poor satiety or stomach dilation.

Talebpour et al. 2012 provided one of the longest follow-up periods showing a gradual but significant increase in weight regain. They stated 5.5% at 4 years increasing to 31% at 12 years. The study suggested that this was largely due to patient non-compliance and the diminishing restrictive effect of LGP over time.

Overall, while LGP initially provides effective weight loss, the durability of its results is compromised by the tendency for the plication fold to stretch or to dissolve. That leads to weight regain. The need for reoperation varies widely across studies ranging from as low as 6% (Gudaityte et al.) to as high as 23.3% (Abdelgawad et al.) reflecting differences in surgical techniques, patient populations, and follow-up durations. Despite these variations, a common trend emerges. Long-term success with LGP is highly dependent on patient adherence to dietary and lifestyle modifications as well as the structural integrity of the plication fold.

8.2. Comorbidities

In bariatric surgery the interest does not solely lie on weight changes but also on the effectiveness in reaching improvements and remission in preexisting comorbidities. Based on the gathered data gastric plication demonstrates significant results in resolving obesity-related comorbidities.
Preoperatively, the most frequently observed comorbidities among the patient populations were arterial hypertension (n=157), type 2 diabetes mellitus (n=235), dyslipidaemia (n=131), fatty liver (FL, n=713), degenerative joint disease (DJD, n=96), gastroesophageal reflux disease (n=24), and obstructive sleep apnoea (OSA, n=14).
The postoperative outcomes showed significant remission rates across almost all of these conditions. Particularly notable was the improvement in diabetes mellitus with a remission or improvement seen in 177 out of 235 diabetic patients (75%). Arterial hypertension also showed strong remission rates with resolution in almost one-third of the patients (34%). Dyslipidaemia as well significantly improved in nearly half of the patients (62 out of 131 patients, 47%). Remarkably, fatty liver disease demonstrated a strong resolution rate with 305 out of 713 patients (43%) achieving remission indicating a huge beneficial metabolic impact. Degenerative joint disease also improved significantly with remission seen in 58 out of 96 patients (approximately 60%). Although GERD and OSA were less frequently reported, gastric plication still showed remission in these conditions with GERD resolving in 6 of 24 patients (25%) and OSA fully resolving in 6 of 14 patients (43%).

Overall, the results from multiple studies clearly indicate gastric plication's effectiveness not only as a weight-loss procedure but also as an efficient surgical option for managing obesity-associated

diseases. The mean remission rate for the different comorbidities across the studies are 73.11% for type 2 Diabetes Mellitus, 78% for patients with dyslipidaemia, 64.43% in arterial hypertension, 21% in gastroesophageal reflux disease reporting it only from one article, 78.33% for fatty liver such as 100% remission rate in obstructive sleep apnoea and degenerative joint diseases.
These numbers show excellent results for obesity-related comorbidities having a big impact on the patients' health.
Thus, gastric plication can be seen as a valuable therapeutic intervention achieving major improvements or complete remission in common obesity-related comorbidities consequently enhancing health and quality of life for patients.

8.3. Technique

Laparoscopic gastric greater curvature plication has evolved with several technical modifications reported across different centres. Despite the common goal of gastric volume reduction by infolding the greater curvature key variations do exist in suture patterns (number of rows, suture material, and stitch configuration), bougie size, and use (or extent) of devascularization. Mean operative time in Talebpour et al. 2012 was reported at 72 minutes ranging from 49 -152 minutes while the mean hospital stay of patients was 72 hours ranging from 24 hours up to 45 days. Gudaityte et al. 2018 had a mean operative time of 91.2 ± 29.5 minutes with a mean hospital stay of 2.9 ± 1.3 days. Doležalova-Kormanova et al. 2017 presented a mean operative time of 69 minutes and patients were staying in average 38 hours with a range from 24-72 hours. The other Articles (Abdelgawad et al., Tsao et al., Najjari et al., Park et al.) did not explicitly give numbers for average operative time or hospital stays. From the articles that reported operative times for laparoscopic gastric plication, they tend to cluster in the 60–90-minute range, and hospital stays are typically around 2–3 days (24–72 hours), though some outliers exist (e.g., up to 45 days in one rare case in the Talebpour cohort).

Early Advocates such as Talebpour et al. introduced gastric plication with multiple approaches—anterior plication, single-row bilateral, or two-row plication—eventually favouring the two-row method for most cases. Two-row extramucosal suture techniques are likewise used by Abdelgawad et al., Tsao et al., Najjari et al., Park et al., and in many of Gudaityte et al. and Doležalova-Kormanova et al. patients. It was reported that a bougie or endoscope ranging from 32 Fr to 38 Fr is typically used intraoperatively to maintain a patent lumen and avert overly tight folds.
Suture materials also differ. Some groups favour polypropylene or Prolene in one or two layers, whereas others have introduced a combination of Ethibond, Ti-Cron, V-Loc, or silk. Certain surgeons (for example in Abdelgawad et al. and Tsao et al.) devascularize the greater curvature to ensure a

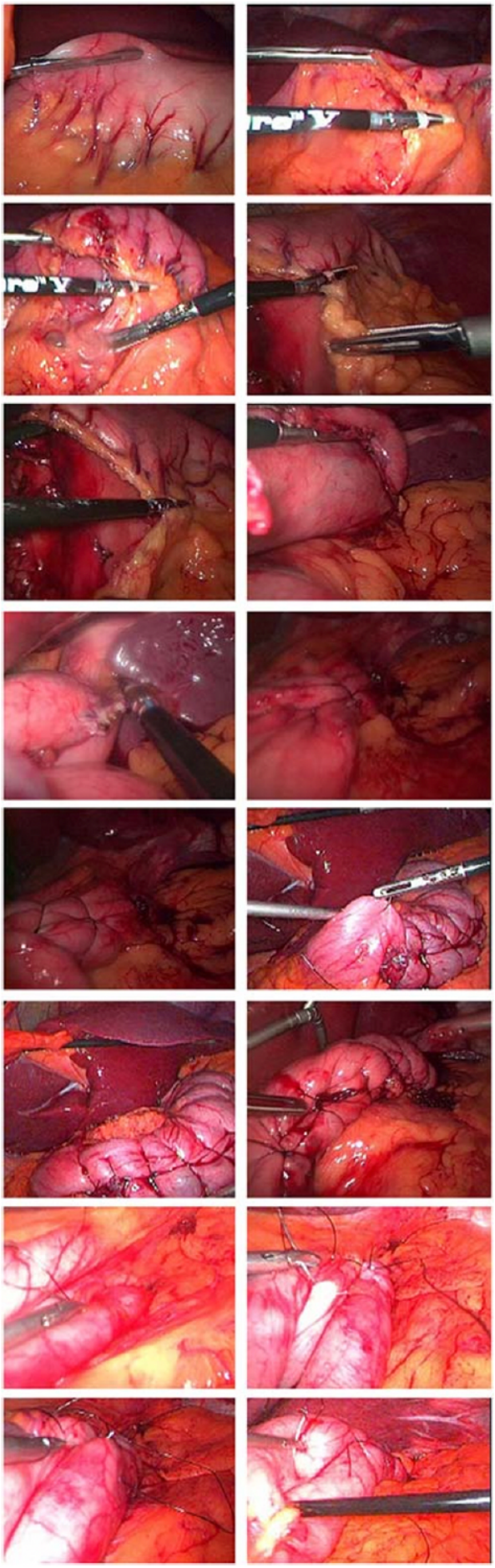

Figure 8 Stages during LPG (24)

more pliable gastric wall prior to plication, though devascularization is not described by all authors. Overall, the fundamental principle remains consistent. The outer curve of the stomach is loosened and folded inward using one or two rows of stitches creating a narrow passage similar to a sleeve gastrectomy but without removing any part of the stomach. These technique variations have not yet been conclusively demonstrated to yield major differences in long-term weight loss or complication rates, though some evidence suggests that more secure two-row strategies may better preserve plication integrity and consequently impact long term results. (22)

8.4. Follow up

Across the articles on laparoscopic gastric greater curvature plication follow-up durations and rates varied. They typically extend from two to six years with some reaching or surpassing the 10- to 12-year mark. Gudaityte et al. 2018 maintained strong early follow-up rates (88–95% over three years), revealing a steady drop in weight-loss parameters and reporting that more than half of patients had an intact plication fold at the three-year mark. Talebpour et al. (2012) reported one of the largest and longest experiences (up to 12 years) with a ~16.7% loss to follow-up, documenting significant weight regain in nearly one-third of patients long-term.

In the medium-term range, Abdelgawad et al. 2022 followed their cohort for six years. Weight loss initially plateaued but then regressed demonstrating a weight regain rate of 58% at six years. Tsao et al. 2022 with a shorter three-year timeframe found

that LGGCP achieved significantly less weight reduction and had a higher reoperation rate. Najjari et al. 2023 similarly followed patients for five years and found a substantial percentage (46.3%) regaining weight by that time. Doležalova-Kormanova et al. 2017 reported 5-year outcomes in over two hundred patients with almost 80% maintaining clinically meaningful weight loss and a mean weight regain of about 9%. Finally, Park et al. 2022 identified a 17.3% revision surgery rate at over five years primarily to address recurrent weight gain.

Taken together, these follow-up studies consistently show that LGGCP often achieves significant early weight loss, but a notable proportion of patients experience progressive or late weight regain beyond two or three years. Variations in follow-up rates and durations make direct comparisons challenging, yet the overall consensus suggests that longer follow-up is essential to understand the true durability of LGGCP, as some patients maintain successful weight loss whereas others face eventual recidivism and require revision procedures.

8.5. Limitations

The majority of the studies included in this review are based on single-centre experiences, which can lead to biases that relate to specific institutions or surgeons making it difficult to apply the findings broadly. While the sample sizes are different, varying from small to large, a major issue across studies is the high dropout rate in long-term follow-ups. That raises concerns about the durability of the results.

Many studies are retrospective which makes them prone to incomplete data collection, selection bias, and limited details on patient characteristics. Even prospective studies face challenges because of differences in surgical techniques such as one-row versus two-row suturing or adjustments made during the study period making direct comparisons difficult. Additionally, the absence of control groups in many studies limits the ability to accurately measure the effectiveness of laparoscopic gastric greater curvature plication (LGGCP) compared to other bariatric procedures. These limitations underline the need for larger, multi-centre, prospective, and ideally randomized trials to provide clearer insights into the long-term safety and effectiveness of LGGCP.

The study Mohammad Talebpour et al. 2012 demonstrated the limitations clearly. It presented several weaknesses that impact the reliability of its findings on laparoscopic gastric plication. As it is seen commonly cited in the field of gastric plication, as it is used as a foundational long-term study with results followed up to 12 years, it was analysed thoroughly. While the authors reported a 16.7% loss to long-term follow-up the actual number of patients included in excess weight loss analyses declines far more significantly over time as already mentioned earlier. As the data are divided into specific follow-up intervals such as 2-year, 5-year, and 12-year assessments the sample size becomes

progressively smaller. For example, after 5 years the study only reports 134 patients for EWL% from the initial 800 patients undergoing surgery. That represents a way bigger loss of long term follows up than the reported 16.7%. This raises concerns that the reported excess weight loss percentage (EWL%) and other long-term weight parameters may not fully represent the outcomes of the original cohort.

Another challenge lies in the multiple technical modifications made to the surgical approach over the study's 12-year period. The procedure evolved from single-row or anterior plication to the more commonly used two-row bilateral plication with refinements such as whether the right gastroepiploic artery was included in the fold. Since all these variations are combined into a single study and dataset it is challenging to determine which specific technique can be seen with the best or worst results. This lack of standardization complicates finding conclusions about the effectiveness of a singular surgical method across all 800 patients.

There also appears to be a discrepancy in reported reoperation rates. The main text states that only 8 patients (1%) underwent reoperation due to acute complications like micro-perforation and obstruction. Yet other sections of the paper reference a total of 53 reoperations (6.6%) for reasons such as weight regain and insufficient weight loss. This inconsistency makes it difficult to accurately assess the true revision surgery rate as it is unclear whether the authors differentiate between early complication-related reoperations and those performed later for suboptimal weight loss.

Additionally, the single-centre nature of the study introduces potential biases. All data come from one hospital in Iran reflecting the experience of a specific surgical team and a particular patient population. Without multi-centre validation or a randomized control group it remains uncertain whether these results are generalizable to other patient demographics or surgical environments.

The study also faces challenges related to heterogeneous follow-up intervals. Although the authors cite a mean follow-up of five years the data include patients with follow-ups extending up to 12 years, and assessments were not standardized across the cohort. Since different patient subsets were evaluated at each time point, comparisons between 2-year, 5-year, and 12-year results become difficult. This variability increases the likelihood that the patients assessed at each interval do not fully represent the broader study population.

Taken together, these limitations make it challenging to draw definitive conclusions about the long-term efficacy, durability, and complication rates of laparoscopic gastric plication as performed in this study.

8.6. Critical appraisal of study heterogeneity

A notable limitation of this literature review is the substantial heterogeneity among the included studies, which complicates direct comparison and weakens the strength of a collective conclusion. The selected studies varied in terms of study design consisting of retrospective and prospective case series,

as well as a single cohort study. Retrospective studies are susceptible to recall bias, incomplete data reporting and lack of standardized follow-up protocols. These factors reduce the reliability of outcome assessments.

The follow-up durations among the studies were also inconsistent ranging from three to up to twelve years. Some studies presented comprehensive long-term outcomes while others were limited to mid-term data. This variability not only affects the ability to compare weight loss and remission rates but also influence the reports of complications. Long-term adverse events for example may be underrepresented in shorter studies.

Furthermore, variations in surgical techniques across the studies should be appraised. Differences were noted in the number of suture rows (single and double), type of suture material, use of bougies or endoscopes, and whether devascularization was performed. These technical differences likely contribute to disparities in outcomes such as plication integrity, weight regain and complication rates. However, these variables were often not clearly described or standardized, issuing further comparability between the studies.

Moreover, most studies lacked control groups or comparison against established bariatric procedures such as LSG or RYGB limiting the ability to compare the effectiveness and safety of gastric plication. Only one study made a direct comparison between LGGCP and sleeve gastrectomy. But even there, differences in patient selection and baseline characteristics limit the strength of the conclusion.

All in all, these inconsistencies emphasize the need for standardized surgical protocols. Moreover, long-term multicentre trials would be important in order to accurately determine the benefits and limitations of gastric plication. Until such data are available, interpretation of existing literature should be approached with caution.

8.7. Comparison with established bariatric surgeries

Comparing LGCP with LSG a few things become clear. LSG has been regarded over the past few decades as an effective and safe treatment for morbid obesity. It has shown good results in reducing weight and improving obesity-related comorbidities. Nevertheless, this procedure involves irreversible gastrectomy in patients. In addition, operative complications and partial mortality were also a concern. The overall rate of incidence was estimated at 0.89%. An emerging alternative bariatric surgery would be LGCP. It achieves similar results in regard to significant weight loss and improvements of associated comorbidities. In comparison, it even offers advantages in terms of reversibility giving the patients the option to preserve the integrity of the stomach. In the systematic review and meta-analysis from Haoran Li et al. 2021 they reported that both procedures are achieving significant weight losses. LSG is having better results in terms of %EWL and BMI loss in the first two years. After three years postoperatively, both comparison groups were achieving similar outcomes. The

results in BMI loss were better for LSG. In regard to long-term weight loss (3 years) they reported better results in LSG as well.

In addition, they mentioned the factor of ghrelin which is a hormone what is playing an important role in regulation of body weight and appetite. The secretion of ghrelin is influencing hunger by raising the motility of the stomach and emptying the stomach resulting in increased appetite. Ghrelin is mostly produced by P/DI cells in the fundus of the stomach. Therefore, the production of this hormone will be significantly lowered after LSG caused by the resection of the fundus of the stomach. Consequently, LSG patients can be having advantages in long term weight loss due to decreased appetite development.

Moreover, peptide tyrosine tyrosine (PYY) has a defining role as well. They are produced in L cells which are found in the colon and the distal ileum. Similar to ghrelin they influence the sense of hunger and have the effect of appetite reduction. There are reports that claim that PYY secretion were not increased after a trial meal in patients after LGCP. In cases after LSG PYY levels were observed to be increased which can explain better results in weight loss after LSG.

Comparing both procedures for the efficacy for improving comorbidities or achieving remission, they evaluated it with not significant differences. Obesity associated comorbidities such as T2DM, arterial hypertension, dyslipidaemia and sleep apnoea were compared. As this current literature review for gastric plicates indicated earlier it can achieve good outcomes as well compared to the well-established methods.

When comparing the surgeries LGCP can be considered as less invasive due to reasons like the potential reversibility of this procedure but in terms of complication rate the meta-analysis showed no advantages on either side. LGCP reported to have statistically higher numbers of nausea and vomiting. This could be explained due to the double row stitching where the stomach folds in the lumen causing mucosal oedema due to venous stasis. Comparing major complications such as bleeding, leakage or mortality rates no significant differences could be reported between the two techniques.

Next to the medical details concerning efficacy and safety, important factors to consider are also economic costs, comparison of operative time and length of hospital stay.

LSG was not reported with statistically shorter time during surgery. Hospital stays were also according to the type of complications, but the meta-analysis demonstrated no significant differences. The cost of LSG was reported as significantly higher in the meta-analysis as it was reported as well in this article. Although the reliability of the cost benefits of LGCP is limited. In the meta-analysis they state that the high heterogeneity of the studies makes it difficult for a conclusion of cost efficacy as only one paper included massive cost differences of (17100$ vs 2620$) (27).

In the articles presented in this paper the only study that provided clear economic figures was Talebpour et al. 2012. The authors reported that cost of LPG was approximately $2000 lower than

compared with gastric banding or sleeve gastrectomy and $2500 lower than in gastric bypass. Nevertheless, the authors do not show statistical values to demonstrate any significance which makes it difficult as well to form a conclusion. Najjari et al. 2023 only briefly reported an "acceptable" cost benefit for gastric plication but does not supply specific details or form of significance. Doležalova-Kormanova et al. 2017 also only mentioned that LGCP is less costly than sleeve gastrectomy but as well did not give any statistical analysis. Gudaityte et al. 2018, Abdelgawad et al. 2022, Tsao et al. 2022, and Park et al. 2022 do not provide any quantitative cost comparisons with sleeve gastrectomy. Therefore, more studies must be conducted to emphasize a better comparison.

Lien – Cheng Tsao et al. 2022 stated their LGCP group showed a more consistent but narrower range of weight loss outcomes, and a higher rate in reoperations compared to the LSG group. Reoperation was required in 11 LGCP patients due to weight regain or inadequate weight loss. However, no complications were reported in the LGCP group, while four of the LSG patients experienced postoperative complications. Three of these complications resolved before discharge, while one patient developed gastric outlet obstruction and required conversion to Roux-en-Y surgery. No deaths were reported in either group. While multiple studies have demonstrated the short- and mid-term effectiveness of LSG, long-term data on LGCP remain limited.

9. Conclusion

Obesity is a disease that is associated with multiple conditions such as heart and vascular diseases, Type 2 Diabetes mellitus or major depressive disorder proposing a major public health risk. With its numbers continuously rising, predicting that more than half of the global population will be obese by 2035, it becomes evident that solutions and therapies are needed. Next to conservative treatments such as dieting, bariatric surgery is gaining prominence in the management of obesity.

This systemic review shows that Laparoscopic gastric greater curvature plication can lead to positive outcomes in regard to long lasting weight loss and significant improvement in obesity – related comorbidities. Moreover, the included articles showed that it is a procedure with low complication rates. It can be seen as a minimal invasive procedure that does not involve any resection or foreign materials in the body which is why it gives patient an option of reversibility.

Nonetheless, it should be emphasized that that current body of evidence is strongly limited. It still lacks clinical trials and literature as indicated in most of the analysed articles. There are small sample sizes, inconsistent methodologies and a lack of long-term data.

Moreover, the existing literature and studies must be considered with caution as well. Studies included showed major weaknesses. As there is limited amount of long-term and large-scale studies the few

existing ones are even more significant. The heterogeneity among the included studies regarding surgical techniques, patient selection, and follow-up durations makes it challenging to draw definitive conclusions about its long-term efficacy and safety.

Therefore, as suggested by the American Society for Metabolic and Bariatric Surgery this procedure should remain an investigational procedure due the lack of data compared to more established bariatric procedures like sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB). Future research should be conducted focussing on standardized, multicentre prospective trials with extended follow-up periods, clearly defined endpoints, and thorough reporting of both weight loss outcomes and comorbidity remission. Only through such studies can the true potential of gastric plication be properly assessed and its role in bariatric surgery more clearly defined.

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