

PROSPECTIVE META-ANALYSIS OF RELEASED WEIGHT LOSS AND SUCCESS RATE OF ARGON PLASMA COAGULATION TO SUTURE AND SURGERY PROCEDURES POST-BARIATRIC SURGERY: STATUS OF THE ART OF ENDOSCOPIC TREATMENT

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Abstract

Introduction: Currently, 30% of the world's population is overweight or obese. Roux-en-Y gastric bypass (BGR) and vertical gastrectomy are the most commonly performed techniques in Brazil and worldwide. **Objective:** Conduct a meta-analysis of the results of using argon plasma coagulation (APC), suture (SUT), and surgery (SUR), to clarify the safety and efficacy of using argon plasma to other procedures. **Methods:** The quality of the evidence was classified as high, moderate, low, or very low, according to the risk of bias. The Variance (α^2) and One-Way (ANOVA) test were applied, adopting the α level less than 0.05 with a statistically significant difference for the 95% CI. The value of R-sq (R2) was analyzed to discover the imprecision or heterogeneity of the analyzes. **Results:** A total of 34 studies were found, eight to APC, twenty to SUT, and six to SUR. For relapsed weight loss (RWL), the means for APC, SUT, and SUR were respectively 19.39 ± 10.94 , 26.06 ± 16.71 , and 17.05 ± 9.85 , and for SR, the means were respectively 89.75 ± 16.75 , 86.80 ± 11.44 , and 76.00 ± 21.57 . There was a small difference between the values of APC averages with SUT and SUR, both in relation to RWL and SR, with $p > 0.05$, with a high association (R2 [?] 50%). **Conclusion:** It was shown that the APC technique showed excellent results in terms of RWL and SR compared to the other techniques, with no statistically significant difference. Thus, the results of the APC strongly point to its potential use.

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INTRODUCTION

Obesity stands out as a multifactorial disease that can cause several public health problems [1]. Currently, 30% of the world's population is overweight or obese. By 2020, it is estimated that more than 60% of the world's population will be overweight or obese. Estimates suggest that the prevalence of severe obesity in 2030 will be 11%, approximately twice the current prevalence [2]. In this context, there are 2.0 billion overweight and obese people in the world [3], and Brazil is in fifth place in the world ranking, with an estimated 18.0 million people, tending to reach over 70.0 million [4]. In 2019, according to a survey carried out by the Ministry of Health, 52.5% of Brazilians are overweight [5].

The Roux-en-Y gastric bypass technique (BGYR) is one of the most performed techniques in Brazil and in the world, together with vertical gastrectomy (around 1: 1) [1]. The Gastric Bypass technique presented in Latin America about 3,195 bariatric operations in 2008, while in 2018 there were 10,852, an increase of 339%. BGYR can promote up to 75.0% of initial excess weight loss in the period of 18 to 24 months but with a long-term failure rate ranging from 10.0% to 35.0% [5,6]. In superobese (BMI > 50), the impossibility of reaching a BMI below 35 can reach up to 60% of cases [8].

Despite this, bariatric surgery can lead to postoperative complications. The most feared complications in the postoperative period, responsible for mortality rates between 0.1 and 0.5%, include sepsis of abdominal origin, caused by suture or anastomosis dehiscence, pulmonary thromboembolism [9,10] and recurrence of obesity, in which the main associated factors are food error and bad lifestyle habits associated with a sedentary lifestyle, resulting in an increased gastric reservoir and consequent dilation of the anastomosis [11,12].

In this sense, the efficacy and safety of narrowing the gastrojejunal anastomosis using the techniques of Argon Plasma Coagulation (APC), Suturing (SUT), and surgical procedures (SUR) in the recurrence of obesity after bariatric surgery is still under discussion [8]. Thus, it is imperative to better know and compare the scientific results among these procedures in order to offer patients an adequate and effective treatment for relapsed weight. Thus, the main endoscopic procedures are the Endocinch, the Stomaphyx, the ROSE procedure, the Overstitch of Apollo Endosurgery, the OTSC clip, and the glare of the gastrojejunal anastomosis with argon described by Aly in 2009 [13].

In this context, the present study aimed to make a systematic review of the literature followed by a meta-analysis by means of statistical treatment on the exponent subject of the reduction of gastrojejunal anastomosis using the three modalities of argon plasma, suturing, and surgery, in order to elucidate more clearly the safety and efficacy of using argon plasma compared to other procedures.

METHODS

Study design

This study followed the international rules of PRISMA's Systematic Review and Meta-analysis [14]. **Table 1** shows the main variables of the present study that will be addressed according to the classification of the acronym PICOS (P = Patients; I = Intervention; C = Control; O = Outcomes; S = Study design).

Search Strategy and Information Sources

The strategy was carried out through the search system in PubMed, MEDLINE, EMBASE, Web Of Science, ScienceDirect Journals, Scopus, OneFile (Gale), OVID, EBSCO, LILACS/ Bireme, and gray literature, following the steps of the search for MeSH Terms Argon plasma coagulation; Endoscopic suturing; Surgery; Weight regain; Bariatric surgery. Also, a combination of the keywords with the Booleans "OR", AND and

the operator “NOT” was used to target scientific articles of interest. The title and abstracts were examined under all conditions. The research structure used in the databases is shown in Table 2. The same search strategy was used in other databases.

Risk of bias

The quality of the evidence was classified as high, moderate, low, or very low, according to the risk of bias, clarity of comparisons, precision, and consistency of the analyzes. The randomized controlled clinical trials (RCTs) have given the highest preference, as it provides high scientific evidence. The quality of the evidence was reduced to moderate if one of the four criteria of quality of the evidence had not been met and lower if 2 or more were not met. Low quality of evidence was attributed to case reports, editorials, and short communications. The Cochrane instrument was to be adopted to assess the quality of the included studies [15].

Eligibility criteria and study selection

The present study selected studies with obese patients who underwent bariatric surgery and who had weight relapse after surgery. The inclusion criteria to compose the meta-analysis were randomized controlled trials, prospective, retrospective studies, case series, Consensus Development Conference and Consensus Development Conference (NIH) that presented a low risk of bias, clarity of comparisons, precision, and consistency of the analyzes, as well as studies with statistically well-prepared results and studies published in indexed newspapers and with a significant impact factor. Exclusion criteria were studies of meta-analysis, reviews, systematic, editorial reviews, letters to the editor, and brief comments.

After these literary search criteria, ninety-six (96) studies involving bariatric surgery, widening of the gastrojejunal anastomosis, weight relapse, use of argon plasma, suturing, and surgery were found. Of this total of articles, thirty-four (34) articles were selected to compose the meta-analysis, according to the rules established by the Cochrane instrument and by the quality of the evidence (Figure 1).

Summary of Literary Findings

The summary of literary findings composed of thirty-six studies involves qualitative and quantitative data such as type of study, number of patients, complications, success rate, weight loss relapsed after bariatric surgery and follow-up on the outcomes of the use of plasma techniques Argon, suturing and surgeries are grouped in Table 3.

Data analysis

The statistical analysis of the data was carried out by the author Dr. Idiberto José Zotarelli Filho, MSc, Ph.D., and interpreted by the other co-authors. For data analysis, a database was built on a Microsoft Excel spreadsheet that was exported to the Minitab 18® statistical program (version 18, Minitab, LLC, State College, Pennsylvania, USA) (Minitab®) [16]. Common descriptive statistical analysis was performed, obtaining the values of total N, mean, standard deviation, confidence interval (CI), and percentage (frequency) for the variables involved. The Variance (α^2) and One-Way (ANOVA) test were applied, adopting the α level less than 0.05 with a statistically significant difference for the 95% CI. The value of R-sq (R2) was analyzed to discover the imprecision or heterogeneity of the analyzes, adopting the codes of low association [?]25%, medium association 25% <X <50%, and high association[?]50%.

RESULTS OF SYSTEMATIC REVIEW AND META-ANALYSIS

Based on the selection criteria and after a systematic review followed by a meta-analysis, as shown in Table 1, the literary findings included the main information from the studies to the techniques used for relapsed weight loss(RWL) after bariatric surgery, rate of success (SR), type of study, number of patients, references and follow-up. A total of 34 studies were found, of which eight (8) papers were published using the argon plasma method (APC) to reduce gastrojejunal anastomosis, twenty (20) papers using the suturing procedure (SUT), and 6 papers using techniques surgeries (SUR).

The intervals in the number of patients evaluated in each procedure were 10 to 558 for APC, 3 to 252 for SUT, and 5 to 116 for SUR. Most studies followed prospective longitudinal studies. The randomized studies were related to one study on (TORe), one on EndoCinch®[®], and one on APC (with crossover) (Table 3). The intervals of the RWL and SR averages of the procedures are shown in Table 3. Thus, for RWL, the averages for APC, SUT, and SUR were respectively 19.39 ± 10.94 , 26.06 ± 16.71 , and 17.05 ± 9.85 , and for SR, the means were, respectively, 89.75 ± 16.75 , 86.80 ± 11.44 , and 76.00 ± 21.57 .

Also, the present study presented the results of the mean, standard deviation, and minimum and maximum values and p-value values of the normality test, with $p > 0.05$ being normal (95% CI), of the APC, SUT, and SUR procedures to RWL and SR. Thus, the results in relation to the RWL showed that the APC and SUR studies showed Gaussian (normal) behavior, with $p = 0.253 > 0.05$ and $p = 0.735 > 0.05$, respectively. The studies on SUT showed non-normal behavior, with $p < 0.005$, as shown in Table 4. The results about SR showed that only SUR studies showed Gaussian behavior, with $p = 0.074 > 0.05$ (Table 5).

The equality of variance test was also performed for further Tukey analysis between the APC, Suturing and Surgery procedures to the RWL and SR of the post-bariatric surgery procedures, with $p > 0.05$ without statistically significant difference (95% CI). Due to the results, they presented equality of variances, both for RWL, with $p = 0.707 > 0.05$ (Figure 2), and for SR, with $p = 0.174 > 0.05$ (Figure 3), followed by Tukey's analysis (ANOVA). This compared the averages of the percentage of RWL and SR of the procedures, with $p > 0.05$ without a statistical difference (CI 95).

Thus, in relation to the RWL, Figure 4 shows that the difference between the means of the SUT vs. APC, SUR vs. APC and SUR vs. SUT were respectively 6.67 ($p = 0.843$), -2.34 ($p = 0.878$) and -9.01 ($p = 0.510$). Figure 5 shows for SR that the difference between the means of the SUT vs. APC, SUR vs. APC and SUR vs. SUT were respectively -2.95 ($p = 0.880$), -13.75 ($p = 0.284$) and -10.80 ($p = 0.343$). Therefore, the results of RWL and SR showed a high association in each comparison between the groups paired above, with R^2 [?] 50% (homogeneity).

DISCUSSION

The recurrence of obesity is associated with decreased quality of life and recurrence of comorbidities in these patients and in this group of patients [17,18]. Thus, endoscopic techniques have been developed in an attempt to effectively reduce the anastomotic diameter and consequent weight loss.

In this sense, the present study presented results of a systematic review followed by a meta-analysis of the works that used the techniques of APC, SUT, and SUR in an attempt to minimize the RWL and its comorbidities. In this context, the works listed in this study, despite the difference in the number of articles found between SUT and APC and SUR, showed that the APC technique showed excellent results in terms of RWL and SR compared to the other techniques, with no statistically significant difference. Thus, the results of the APC strongly point to its potential use.

Added to this, an important data was demonstrated by the results of Table 4 of this study, since the normal behavior in relation to the APC RWL results showed greater precision of the values obtained, that is, by the meta-analysis, the APC technique showed homogeneity of the results. results, proving that it is an efficient and effective technique.

Another notorious result was presented by Figures 4 and 5 of the present study, revealing that there was little difference between the values of the means of the APC with SUT and SUR, both in relation to RWL and SR, and all comparisons did not present significant statistical difference. by Tukey's analysis. These findings clearly show that the endoscopic use of APC is as safe and efficient as the SUT and SUR techniques, showing a high association in each comparison between the paired groups, with R^2 [?] 50% (homogeneity).

As a corollary of weight gain recurrence in the studies evaluated in this meta-analysis work, abnormal anatomical findings are found in 71.2% of the patients, 58.9% with gastrojejunoanastomosis dilation, 28.8% with pouch dilation, and 12.3% with changes in both [13]. Thus, several methods such as endoluminal reduction of gastrojejunal anastomosis: - endocinch (Bard(r), Billerica, Massachusetts); Rose procedure: - restorative

obesity surgery, endoluminal (USGI(r), San Clemente, CA); Stomaphyx (Endogastric Solutions(r), Redmond, Washington); OTSC Clip (Ovesco AG(r), Tubingen, Germany); Overstitch (Apollo Endosurgery(r), Inc Austin, TX) and fulguration of the gastrojejunal anastomosis with argon have been proposed to reduce weight in patients undergoing gastric bypass [13].

Thus, surgical treatments are the most performed, however, they are associated with a higher incidence of complications and morbidity and mortality when compared to the other treatments proposed above [8-10]. Suturing techniques in the gastrojejunal tract have been used to manage complications over years of clinical practice. In this sense, the Endocinch suture system (C.R. BARD, Inc, Murray Hill, NJ, USA) was developed for the endoscopic treatment of gastroesophageal reflux disease (GERD) [19]. Endoscopic sutures are placed in the cardia in order to reduce and narrow the esophageal-gastric transition.

Thus, Thompson et al. (2006) demonstrated the applicability of this method in 8 patients with post-gastric bypass weight regain with dilated gastrojejunal anastomosis. The mean diameter of the anastomosis was 25 mm and after the procedure, there was a reduction of 68% of the diameter (mean final diameter of 10 mm). The percentage of loss of excess weight was 23.4% [18]. In 2010, the same authors demonstrated the applicability of this method in 220 patients with an average of 4 sutures in the anastomosis and its reduction to less than 10mm in diameter in 89% of patients [20].

Stomaphyx (Endogastric Solutions) was approved by the Food and Drugs Administration (FDA) in 2007 and consists of the suction of the operated gastric tissue (pouch and anastomosis), forming a fold and the same is fixed with an "H" shaped device. Thus, Mikami et al. 2010 submitted 39 patients to endoscopic therapy with Stomaphyx (Endogastric Solutions, Redmond, Washington). All patients had previously undergone gastric bypass and had regained weight after 24 months. The average weight loss in 1 year was 10.0 kg and without noticeable complications [21].

In addition, the Endoscopic System - Over the Scope Clip - OTSC CLIP (OVESCO AG) consists of a nitinol clip positioned on a cap at the end of the endoscope, in order to reduce the diameter of the gastrojejunal anastomosis in patients with post-weight regrowth - gastric bypass. As an example, Heylen et al. (2011) performed this procedure in 94 patients after gastric bypass who had an average dilated gastrojejunal anastomosis of 35 mm in diameter and a 10% weight regain. 1 to 2 clips were applied on average and the final mean anastomotic diameter was 8.0 mm, with an average reduction of 80%. The BMI in 1 year of follow-up reduced from 32.8 kg m⁻² to 27.4 kg m⁻² on average [22].

Furthermore, the OVERSTITCH endoscopic suture platform (APOLLO ENDOSURGERY), is based on a dual-channel endoscope with a suture system and the purpose of reducing the diameter of the gastrojejunal anastomosis in patients with post-bypass gastric weight regain. Preliminary results in 8 patients in Chile showed a reduction in the diameter of the anastomosis from 20.0 mm to 10.0 mm and a loss of 6.0-8.0 kg in 3 months [23].

Surgical procedures are performed with an endosurgical operating system and a small flexible endoscope for viewing. In 2010, Horgan et al. performed this procedure in 116 patients with post-gastric bypass weight regain, demonstrating a 50.0% reduction in the diameter of the anastomosis and 44.0% in the length of the pouch. Six months after the procedure, there was a 32.0% reduction in the weight recovered [24].

Regarding therapy with the gastrojejunal application with an argon plasma, it is important to note first that argon is an odorless, inert, non-toxic, inexpensive, and easily ionizable gas, it has been used in conventional surgeries since the 1980s and, in the field of endoscopy, was introduced in 1991 [25].

There are countless endoscopic applications of fulguration with an argon plasma, such as gastrointestinal bleeding of the most diverse etiologies, tissue growth after stent implantation, the opening of the lumen of hollow organs obstructed by tumor growth, a section of the parenchyma of solid organs such as liver and spleen, and more recently, in the field of bariatric endoscopy [25,26].

The use of AP in the treatment of anastomosis has stood out as an effective and safe method in the treatment of obesity relapse, although there are few studies since endoscopic AP is very effective in its indications,

technically easy to be performed, and with numerous advantages over the usual electrocoagulation. Complications are rare. The depth limit of tissue penetration of 2 to 3 mm associated with excellent coagulation allows its application in critical areas such as the duodenum and the colon [27].

In the case of gastrojejunal anastomosis, fulguration with argon has promoted a reduction in its diameter and consequent delay in gastric emptying, early satiety, and weight reduction [8,28]. Reducing the diameter of a dilated anastomosis can lead to a 23.0% reduction in excess weight [29]. From an endoscopic point of view, information such as the diameter of the anastomosis, complications after bariatric surgery, monitoring by a specialized team, and physical activity contribute to a better indication criterion to be adopted in patients who regained weight after gastric bypass [30]. Thus, the relevance of studies on the effect of argon on weight reduction in patients undergoing gastric bypass points to its increasing use [8].

In this context, a study compared the relative efficacy of TORe and the use of argon plasma coagulation at 3 and 6 months in the treatment of weight recovery after gastric bypass (RYGB). Ten consecutive patients submitted to TORe using an interrupted tissue plication were included. These were combined with 20 patients undergoing argon plasma. The mean age was 50.9 \pm 1.7 years with a pre-RYGB BMI of 46.7 \pm 1.1 kg m⁻². Nadir's BMI was 28.8 \pm 0.8 kg m⁻² (SCHULMAN et al., 2013). The TORe was performed 10.5 \pm 0.9 years after RYGB, with a pre-TOR BMI of 36.6 \pm 1.0 kg m⁻². The average opening of JGA was 18.5 \pm 0.7 mm. The average number of treatments with APC was 1.3 (range 1-4). There were no major adverse events. Weight loss results were better for patients undergoing plication, both at 3 and 6 months. Larger and longer-term studies are needed to assess differences in the durability of these results [29].

A retrospective study was also carried out by De Souza et al (2015) with 37 participants. In this work, the use of argon plasma had a success rate of 50% and a 24.0% reduction in relapsed weight [30]. In addition, a prospective controlled longitudinal study with APC conducted by Cambi et al (2015) showed a success rate of 90.0% and a reduction of up to 41% in weight with recurrence [31].

In addition, a recent randomized controlled clinical study with the crossover between APC and multidisciplinary management evaluated the efficacy and safety of endoscopic treatment of increased anastomosis and weight relapse. Forty-two patients were divided into two APC (n = 22) and control (n = 20) groups. After 14 months of follow-up with a crossover at 6 months, significant improvement in satiety and greater weight loss was found in the APC group, as well as after the crossover. APC was associated with significant weight loss (9.73 (7.46, 12) vs. + 1.38 (- 1.39, 2.15)), a reduction in the diameter of the anastomosis (p < 0.001), early satiety and increased quality of life measured using the EQ5D index and the EQ5D VAS scale. The average weight loss over the entire follow-up was similar in both groups (13.02 kg in the APC and 11.52 kg in the control). Thus, this study showed that the treatment of gastrojejunal anastomosis with APC was effective and safe [32].

Another randomized controlled study analyzed ablation with argon plasma coagulation (APC) with or without full-thickness endoscopic suture (FTS-APC) for the treatment of weight gain when associated with gastrojejunal dilation. Patients with at least 20% of nadir weight recovery and GJ [?] 15 mm were considered eligible. Forty patients who met the eligibility criteria were enrolled from October 2017 to July 2018. The technical and clinical success rates were similar between groups. At 12 months, the mean% TWL was 8.3% \pm 5.5% in the APC group alone versus 7.5% \pm 7.7% in the FTS-APC group (p = 0.71). The% pre-revisional solid gastric retention in 1 hour was positively correlated with the probability of reaching [?]10% TWL in 12 months. Both groups experienced significant reductions in low-density lipoprotein and triglyceride levels in 12 months, and improvement in eating behavior and quality of life in 3 months. There were 2 cases of stenosis (1 from each group), which were successfully treated with endoscopic balloon dilation [33].

In addition, a multicenter study comprising eight centers performed a retrospective review of medical records and analyzed the effectiveness of APC for weight recovery in terms of weight loss in RYGB patients. The study analyzed data from 558 patients in eight bariatric centers in the USA (1) and Brazil (7) who underwent the APC procedure between July 31, 2009, and March 29, 2017. As a result, the mean BMI decreased slightly

during the first 24 months. The average weight was 94.5 ± 18.6 kg and the average BMI was 34.0 kg / m² in the APC. The average weight loss was 6.5, 7.7 and 8.3 kg at 6, 12, and 24 months, respectively, and the changes in weight over time were statistically significant (p < 0.0001). Of the 333 patients in four centers who provided information on complications, complications after PCA included stenosis (n = 9), GJ ulcer (n = 3), vomiting (n = 3), GJ leak (n = 2) and melena (n = 1). Thus, APC can be useful in reducing the weight recovered after RYGB, and patients experienced 6-10% total weight loss in 12 months. [34].

In addition, a single-center retrospective study compared the effectiveness of different APC configurations for the treatment of weight recovery. Patients who received only low-dose APC (45-55 W) or high-dose APC (70-80 W) were compared. Two hundred and seventeen patients met the inclusion criteria and underwent 411 APC sessions. Of these, 116 (53.5%) patients underwent 267 low-dose PCA sessions (2.4 ± 1.5 sessions / patient) and 101 (46.5%) patients underwent 144 high-PCA sessions. dose (1.4 ± 0.7 sessions / patient). Follow-up rates were 82.9% and 75.3% at 6 and 12 months. At 6 months, the low and high dose groups experienced 7.3% ± 6.6% and 8.1% ± 7.4% TWL, respectively (p = 0.41). At 12 months, the low and high dose groups experienced 5.1% ± 8.5% and 9.7% ± 10.0% TWL, respectively (p = 0.008). Technical success was 100%. The overall complication rate was 8.0%, involving gastrojejunal stenosis (4.6%) [35].

In this scenario, to consolidate and confirm the findings of the present meta-analysis study, a meta-analysis study summarized the efficacy and safety of full-thickness suture plus mucosal coagulation with argon plasma (ft-TORe) and mucosal coagulation with argon plasma alone (APMC-TORe). Nine ft-TORe studies (n = 737) and seven APMC-TORe studies (n = 888) were included. The percentage of total body weight loss was 8.0%, 9.5%, and 5.8% after ft-TORe and 9.0%, 10.2%, and 9.5% after APMC-TORe in 3, 6, and 12 months, respectively, with no difference in weight loss at 3 and 6 months. Only one serious complication was observed after APMC-TORe and none after ft-TORe. Therefore, both ft-TORe and APMC-TORe offer significant and comparable weight loss results with a high and comparable safety profile, however, several endoscopic sessions on the APMC-TORe were required [36].

Finally, a prospective study with 252 patients with RYGB determined the technical viability and safety of TORe in the bag and assessed its impact on weight and metabolic profiles. A suture was used to place stitches around the JGA in a continuous ring. The suture was tightened over a balloon (8 - 12 mm). Patients with RYGB underwent 260 TORes in the bag. They had recovered 52.6 ± 46.4% of the weight lost and weighed 107.6 ± 24.6 kg. The technical success rate was 100%. At 6 and 12 months, the % TWL was 9.6 ± 6.3 and 8.4 ± 8.2. Two serious adverse events (0.8%) occurred gastrointestinal bleeding and JGA stenosis. At 12 months, blood pressure, hemoglobin A1c and ALT improved. Thus, the TORe in the bag to treat weight recovery after the RYGB proved to be technically feasible and safe. In addition, it is associated with improved weight profile and comorbidities up to 12 months after the procedure [37].

LIMITATIONS

There was a difference in the number of articles found between SUT and APC and SUR. Still, based on the statistical significance of the increase in the number of bariatric surgeries such as gastric bypass and/or sleeve gastrectomy and consequently its complications, such as the enlargement of the gastrojejunal anastomosis, it is imperative to carry out more randomized and controlled studies, all with greater series and follow-up at least one year.

CONCLUSION

Through systematic review and meta-analysis, it was shown that the results of relapsed weight loss and success rate after bariatric surgery with the use of argon plasma fulguration were as safe and effective as the surgical and suturing procedures.

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Nil.

CONFLICT-OF-INTEREST STATEMENT

The authors declare they have no conflict of interest.

DATA SHARING STATEMENT

No additional data are available.

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Table 1. PICOS (PATIENTS; INTERVENTION; CONTROL; OUTCOMES; STUDY DESIGN).

PATIENTS	Relapsed weight after bariatric surgery
INTERVENTION	Endoscopy treatment with argon plasma coagulation
CONTROL	Endoscopy treatment with suturing and surgery
OUTCOMES	Relapsed weight loss and success rate
STUDY DESIGN	Randomized controlled trials; Prospective; retrospective studies, case series

Table 2. Example of the research structure in PubMed as a model.

PubMed	<i>Argon plasma coagulation OR Endoscopic suturing OR Surgery OR Weight regain OR Bariatric surgery</i>
PubMed	AND <i>Randomized controlled trials OR Prospective OR Retrospective studies OR Case series OR Consensus Development Conference OR Consensus Development Conference (NIH) Aest</i>
PubMed	NOT <i>Meta-analysis OR Reviews OR Systematic review OR Editorial OR Letter to the editor OR Brief comments</i>

Figure 1. Flow chart.

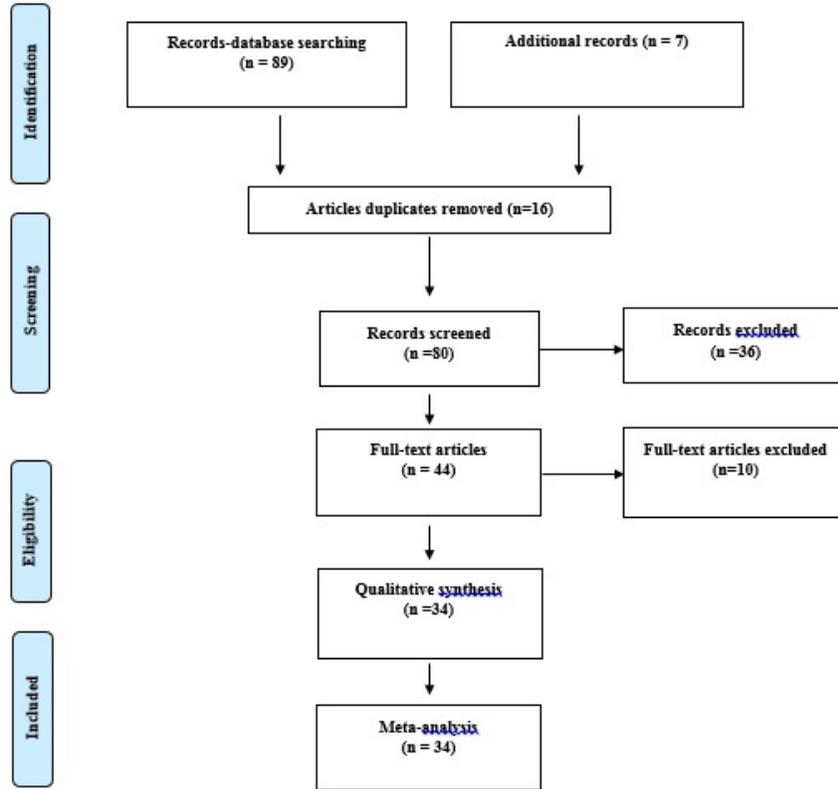


Table 3. Summary of literary findings including the main information from the studies in relation to the techniques used for weight loss recurrent after bariatric surgery, success rate, type of study, number of patients, references, and follow-up.

Reference	Country	Patients Number	Study type	Technique	Complications	Procedure success rate (%)	Relapsed weight loss (%)	Follow up (months)
SUTURING (n = 20 studies) Thompson et al 2013 [38]	USA	77	Randomized clinical trial	Transoral outlet reduction (TORe)	Minor complications	96	15	6
[Jirapinyo, Kröner, Thompson, 2017 [37]	USA	252	Prospective study	Purse-string - TORe	Gastrointestinal bleeding and gastro-jejunal stenosis (0.8%)	100	8.4	12
Jirapinyo et al 2011 [39]	USA	9	Matched cohort study	OverStitch	1 stenosis, 1 emesis	98	20	12

Reference N _{Total} =34	Country	Patients Number	Study type	Technique	Complications	Procedure success rate (%)	Relapsed weight loss (%)	Follow up (months)
Kumar et al 2013 [40]	USA	118	Prospective	Superficial-thickness TORe versus full-thickness TORe	None	90	18	12
Heylen et al 2011 [22]	USA	94	Prospective	Over the Scope Clip	None	70	16.5	6
Rodriguez et al 2013 [41]	Chile	31	Retrospective	OverStitch	None	87	17	24
Fernández-Esparrach et al 2010 [42]	USA	6	Prospective	EndoCinch®	None	95	35	19
Thompson et al 2006 [18]	USA	8	Prospective	EndoCinch®	None	80	23.4	4
Thompson et al 2010 [20]	USA	220	Randomized	EndoCinch®	None	89	60	6
Brethauer et al 2012 [45]	USA	18	Prospective	RESTORE endoscopic suturing device	None	80	27.7	12
Abu Dayyeh et al 2015 [6]	USA	10	Multiple series	OverStitch	None	90	30	6
Sharaiha et al 2015 [46]	USA	25	Prospective	OverStitch	None	90	18.7	12
Lopez-Nava et al 2016 [47]	Spain	10	Prospective	OverStitch	None	90	54	12
Lopez-Nava et al 2016 [47]	Spain	8	Prospective	OverStitch	None	85	45	20

Reference	Country	Patients Number	Study type	Technique	Complications	Procedure success rate (%)	Relapsed weight loss (%)	Follow up (months)
Kumar N et al 2015 [48]	USA	126	International multi-center series	OverStitch	None	90	14.5	6
Kumar N et al 2015 [48]	USA	126	International multicenter series	OverStitch	None	90	19.5	12
Mikami <i>et al</i> 2010 [21]	USA	39	prospective series	Stomaphy X	Sore throat, epigastric pain in most of the patients (76.9%)	87	19.5	12
Leitman <i>et al</i> 2010 [49]	USA	64	prospective series	Stomaphy X	2 (3%) intraoperative complications	79	10	5.8
Manouchehri <i>et al</i> 2011 [50]	Canada	14	Retrospective Study	Stomaphy X	Headache, back pain	100	11	6
Galvao Neto <i>et al</i> 2011 [23]	Brazil	8	Retrospective Study	OverStitch	1 hematemesis	50	28	3
SURGERY (n = 06 studies)	SURGERY (n = 06 studies)	SURGERY (n = 06 studies)	SURGERY (n = 06 studies)	SURGERY (n = 06 studies)	SURGERY (n = 06 studies)	SURGERY (n = 06 studies)	SURGERY (n = 06 studies)	SURGERY (n = 06 studies)
Mullady <i>et al</i> 2009 [51]	USA	20	prospective series	surgery endolumenal	None	60	7.3	3
Ryou <i>et al</i> 2009 [52]	USA	5	prospective series	surgery endolumenal	None	60	6.5	3
Horgan <i>et al</i> 2010 [24]	USA	116	prospective multicenter series	surgery endolumenal	None	97	32	6
Thompson <i>et al</i> 2012 [53]	USA	66	prospective multicenter	surgery endolumenal	None	97	14.5	12
Thompson <i>et al</i> 2012 [53]	USA	60*	prospective multicenter	surgery endolumenal	None	92	24	12
Gallo <i>et al</i> 2015 [43]		27	retrospective	surgery endolumenal	None	50	18	72

Reference N _{Total} =34	Country	Patients Number	Study type	Technique	Complications	Procedure success rate (%)	Relapsed weight loss (%)	Follow (month)
ARGON PLASMA COAG- ULA- TION (n = 08 studies) Cambi et al 2015 [31]	ARGON PLASMA COAG- ULA- TION (n = 08 studies) Brazil	ARGON PLASMA COAG- ULA- TION (n = 08 studies) 49	ARGON PLASMA COAG- ULA- TION (n = 08 studies) Prospective	ARGON PLASMA COAG- ULA- TION (n = 08 studies) Argon Plasma	ARGON PLASMA COAG- ULA- TION (n = 08 studies) None	ARGON PLASMA COAG- ULA- TION (n = 08 studies) 90	ARGON PLASMA COAG- ULA- TION (n = 08 studies) 41	ARGON PLASMA COAG- ULA- TION (n = 08 studies) 12
Souza et al., 2016 [44]	Brazil	10	Cases series	Argon Plasma	None	90	23.5	1
Baretta <i>et al</i> 2015 [8]	Brazil	30		Argon Plasma	2 severe stenosis	90	23	Decreas mean B and me diameter (P<0.05)
De Souza et al 2015 [30]	Brazil	37	Retrospective	Argon Plasma	None	50	24	16
De Quadros et al. 2020 [32]	Brazil	42	Randomized clinical trial with crossover	Argon Plasma	None	100	15.6	14
Moon et al. 2018 [34]	Brazil and USA	558	Multicenter retro- spective (8 centers)	Argon Plasma	Stenosis (n = 9), GJ ulcer (n = 3), vomit- ing (n = 3), leakage of GJ (n = 2) and melena (n = 1)	100	10.0	24
Jirapinyo et al. 2020 [35]	USA and Brazil	267	Single- centered retrospective	Low and high dose Argon Plasma	Gastrojejunal stenosis (4.6%)	100	Low dose: 5,1 High dose: 9,7	12

Reference N _{Total} =34	Country	Patients Number	Study type	Technique	Complications	Procedure success rate (%)	Relapsed weight loss (%)	Follow (month)
Brunaldi et al., 2020 [33]	Brazil	40	Randomized clinical trial	Argon Plasma	Two cases of stenosis	98	8.3	12

*** Patients still had anchors in place, underscoring the efficacy of outlet reduction.**

**** *incisionless operating platform - IOP***

Table 4. Results of the mean, standard deviation, and minimum and maximum values and p-value values of the normality test, with $p > 0.05$ being normal (95% CI), of the argon plasma, suturing, and surgical procedures in relation to loss of relapsed weight.

Relapsed weight loss (%)

Relapsed weight loss (%)

Total

Mean

StDev

Min

Max

Argon Plasma

8

19,39

10.94

8.30

41.00

Suturing

20

26.06

16,71

8.40

65.00

Surgery

6

17.05

9.85

6.50

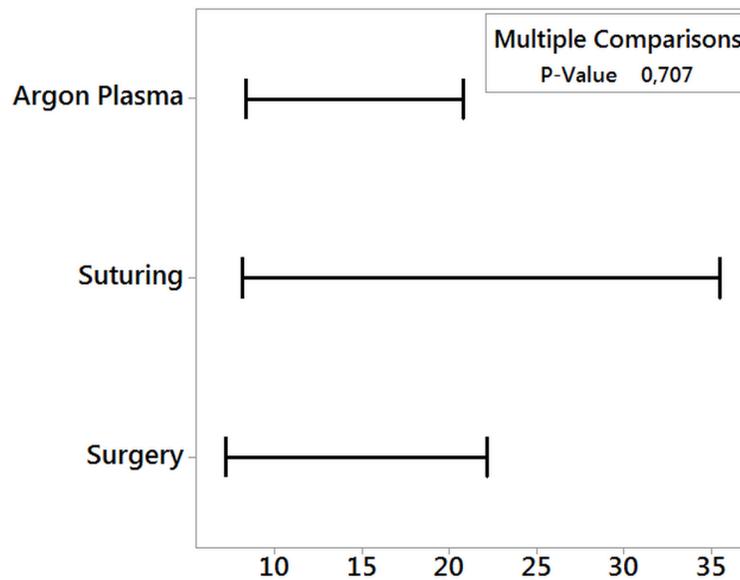
32.00

Table 5. Results of the mean, standard deviation, and minimum and maximum values and p-value values of the normality test, with $p > 0.05$ being normal (95% CI), of the argon plasma, suturing, and surgical procedures in relation to the success rate.

Procedures	Total	Mean	StDev	Min	Max
Success Rate					
%					
Argon Plasma	8	89.75	16.75	50.00	100.00
Suturing	20	86.80	11.44	50.00	100.00
Surgery	6	76.00	21.57	50.00	97.00

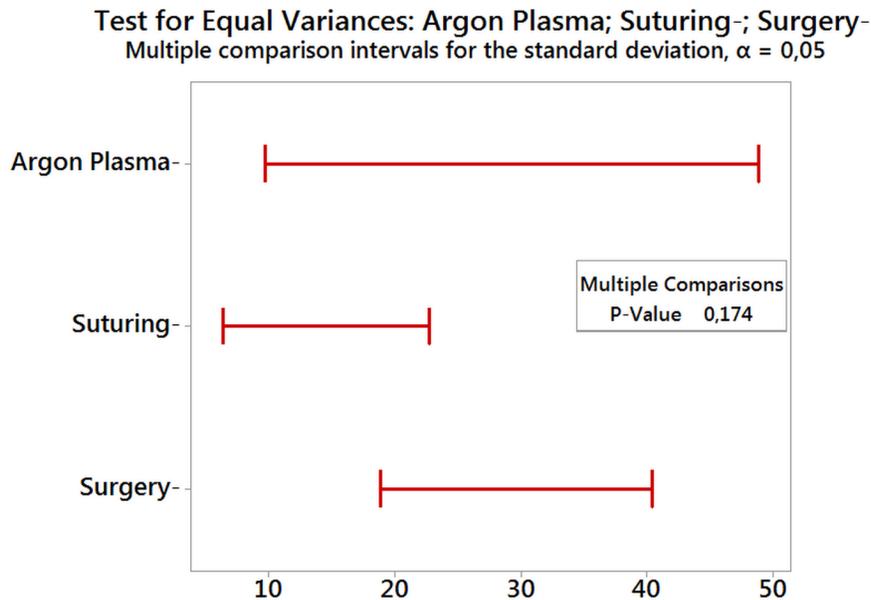
Figure 2. The result of the test of equality of variance between the procedures of APC, Suturing and Surgery in relation to the weight loss recurred after bariatric surgery, with $p > 0.05$ without statistically significant difference (95% CI).

Test for Equal Variances: Argon Plasma; Suturing; Surgery
Multiple comparison intervals for the standard deviation, $\alpha = 0,05$



*** If the intervals do not overlap, the corresponding stdevs are significantly different.**

Figure 3. Result of the test of equality of variance between the procedures of APC, Suturing and Surgery in relation to the success rate of the procedures, with $p > 0.05$ without statistically significant difference (95% CI).



* If the intervals do not overlap, the corresponding stdevs are significantly different.

Figure 4. The result of Tukey’s analysis (ANOVA) the comparison between the averages of the percentage of recurrent weight loss, with $p > 0.05$ without a statistical difference (CI 95), assuming equality of variances.

Difference of Levels

Difference

of Means

SE of

Difference

95% CI

T-Value

Adjusted

p-Value

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted p-Value
Suturing - Argon Plasma	6.67	6.12	(-11.84; 18.82)	1.09	0.843
Surgery - Argon Plasma	-2.34	7.90	(-23.68; 15.84)	-0.30	0.878
Surgery - Suturing	-9.01	6.81	(-23.70; 8.87)	-1.32	0.510

Difference of Levels

Difference

of Means

SE of

Difference

95% CI

T-Value

Adjusted

p-Value

Difference of Levels Difference of Means SE of Difference 95% CI T-Value Adjusted p-Value Suturing - Argon Plasma -2.95 6.18 (-18.55; 12.45) -0.48 0.880 Surgery - Argon Plasma -13.75 7.98 (-32.55; 7.41) -1.72 0.284 Surgery - Suturing- -10.80 6.88 (-25.98; 6.94) -1.57 0.343