

Long-Term Efficacy and Safety of Duodenal Mucosal Resurfacing on Metabolic Improvement: A Systematic Review and Meta-analysis

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Abstract

Introduction

Endoscopic approaches have been introduced for weight loss and metabolic disease management. Duodenal mucosal resurfacing (DMR) is an emerging endoscopic technique used to treat these conditions. This meta-analysis aims to evaluate the efficacy and safety of DMR.

Methods

We searched PubMed, Scopus, and Cochrane databases up to November 2025. The primary outcomes were weight loss, hemoglobin A1c (HbA1c), fasting plasma glucose (FPG), and urine microalbumin levels, with follow-up periods up to 24 months. Secondary outcomes included C-peptide, fasting insulin, Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) score, liver function, lipid profiles, adverse events, and patient-reported treatment satisfaction. A subgroup analysis was conducted specifically for patients with type 2 diabetes mellitus (T2DM).

Results

A total of 16 studies involving 356 patients who underwent DMR were included. Over 24-month follow-up, patients treated with DMR demonstrated significant weight loss (MD: -2.50 kg; 95% CI: -2.60 to -2.39) and FPG levels (MD: -2.01 mmol/L; 95% CI: -2.43 to -1.60). In subgroup analyses of T2DM, DMR was associated with significant reductions in HbA1c (MD: -0.64% ; 95% CI: -1.11 to -0.16) and insulin resistance as measured by HOMA-IR (MD: -3.93 ; 95% CI: -6.78 to -1.09). Notably, 59% of patients remained insulin-independent at the end of the study period. Patient-reported outcomes showed favorable treatment satisfaction.

Conclusion

Modest but durable improvements in weight loss and glycemic outcomes were observed among patients who underwent DMR across diverse settings, with a favorable safety profile. These findings suggest DMR warrants further investigation as an adjunctive option for metabolic disease management.

Introduction

Metabolic syndrome, a combination of conditions including obesity, dyslipidemia, insulin resistance, and hypertension, significantly increases the risk of developing diabetes mellitus and cardiovascular diseases.¹ It is estimated to affect around 30-40% of adults worldwide, with a continuing upward trend in recent years.² While the initial treatments include lifestyle modifications and medication,³ bariatric surgery has become an important definitive therapy, especially for individuals who failed to achieve therapeutic goals after the first-line management.⁴

Although highly effective, conventional bariatric procedures are associated with long operative and anesthetic induction time, and prolonged hospitalization, especially in patients with multiple comorbidities.⁵ These drawbacks of conventional bariatric surgery have driven the emergence of endoscopic bariatric and metabolic therapies (EBMTs) with the key advantage being minimally-invasive, resulting in lower operative time and risks.⁶ Established EBMTs such as endoscopic sleeve gastropasty, primary obesity surgery endoluminal, and intragastric balloon have proven beneficial in patients who do not meet surgical criteria.^{7,8} These interventions primarily promote weight loss through gastric volume restriction, resulting in direct caloric reduction.^{9,10} However, they do not address the indirect

hormonal dysregulation underlying the metabolic syndrome. This encourages the development of Duodenal Mucosal Resurfacing (DMR), a novel EBMT, which mimics the enhanced incretin effect observed in Roux-en-Y Gastric Bypass (RYGB), a conventional bariatric technique that involves bypassing the duodenum.¹¹

DMR is performed by selectively ablating the duodenal mucosal lining to disrupt abnormal villous tips and regenerate normal tissue,¹² aiming to recondition the dysregulated enteroendocrine signaling pathways, which have been suggested by basic biomedical studies as the underlying mechanism in altered glucagon-like peptide 1 (GLP-1), glucose-dependent insulintropic polypeptide (GIP), peptide YY, and gut microbiome, resulting in insulin resistance and metabolic dysfunction.^{13,14} This concept gives DMR a potential benefit in both metabolic regulation and weight control.

Early clinical studies have demonstrated DMR's promising profile in managing metabolic diseases with low adverse events rate.^{15,16,17} This meta-analysis aimed to evaluate the efficacy and safety outcomes of DMR across various conditions to provide a better understanding of its role and application in the management of metabolic syndrome.

Methods

Our meta-analysis has been registered in the International Prospective Register of Systematic Reviews (PROSPERO, CRD No. 420251181910) and written according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Search strategy

We searched for articles published up to November 2025 through the following databases: PubMed, Scopus, and Cochrane.

Primary outcomes were weight loss, hemoglobin A1c (HbA1c), fasting plasma glucose (FPG), and urine microalbumin levels following DMR, with follow-up periods of up to 24 months. Secondary outcomes included C-peptide, fasting insulin, Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) score, liver function, lipid profiles, adverse events, patient-reported satisfaction, and technical success rate. We searched for terms related to "duodenal mucosal resurfacing" and "duodenal ablation". The full search strategy is illustrated in **Supplementary Table S1**. The references of the included articles were further sought through to expand our list of relevant studies.

Selection criteria

We included randomized controlled trials, cross-sectional studies, case-control studies, or cohort studies evaluating the metabolic outcomes and rate of adverse events of DMR. Inclusion criteria are adult (> 18 years old) patients with BMI over 24 kg/m² who have undergone DMR. Exclusion criteria are type 1 diabetes mellitus or patients who have previously undergone bariatric surgery. Case reports, case series, review articles, abstract and conference papers were excluded. Moreover, studies not reporting outcome as mean $\pm$ standard deviation (SD), median (interquartile range [IQR] Q1-Q3), odds ratio (OR), hazard ratio (HR), relative risk (RR), or proportions were excluded. Sample size, specific conditions, and ethnicity of the population were not limiting factors for inclusion.

Data abstraction

Data on study-related, participant-related and intervention-related parameters were retrieved into a standardized data record form by two investigators (Nattawin S. and Nicharorn S.) independently; Using a structured form, the

following information was collected from the included studies: (1) Basic information of literature: title, year of the study, name of the first author, study type, publication year, the country where the study was conducted, recruitment and follow-up period, funding and conflict of interest. (2) Patient baseline characteristics, demographic data, underlying diseases, included population inclusion and exclusion criteria, sample size, and intervention subtypes. (3) OR and HR with 95% confidence interval (CI), proportions, mean and mean difference, median and median difference, SD, and IQR of the outcomes of interests.

For each outcome, the longest available follow-up was extracted. If multiple timepoints were reported, earlier follow-up durations were not used unless the longest follow-up was missing the outcome or reported low follow-up rate (< 40%), in that case the next longest available timepoint was selected. If multiple publications investigating overlapping cohorts were available, we included only one study that has the longest follow-up time, per unique cohort per outcome to prevent double counting.

Quality assessment

Quality assessment of included trials was conducted using the Cochrane Risk of Bias 2 tool for randomized controlled trials, consisting of 5 domains. Each of the domains were given an evaluation of “low risks”, “some concerns”, or “high risks”. The Newcastle-Ottawa assessment scale was used for quality appraisal of the case-control, cohort, and cross-sectional studies. Assessment encompassed 3 domains: study group selection (S) consisting of 4 items with a maximum score of 4, group comparability (C) with 2 items and a maximum score of 2, and exposure and outcome (O) including 3 items and a maximum score of 3. Bias assessment results were presented as numerical values. Data was assessed independently by two investigators (Nattawin S. and Nicharorn S.). All disagreements were resolved by the third investigator (Noppachai S.).

Statistical analysis

The data analysis was conducted using R version 4.5.0. Heterogeneity was assessed using I^2 statistics, with values of 25%, 50%, and 75% representing low, moderate, and high heterogeneity, respectively. A random-effects model with the DerSimonian-Laird method was used to account for between-study variability. For each outcome, the longest available follow-up data were extracted; follow-up durations included studies ranging from 6 to 24 months. Effect estimates were presented as mean differences or proportions with 95% confidence intervals. To minimize confounding factors, univariable and multivariable data were analyzed independently. Subgroup analyses were performed by disease condition (T2DM, non-alcoholic steatohepatitis, polycystic ovarian syndrome) and by DMR technique (hydrothermal, electroporation, radiofrequency). Publication bias was assessed using funnel plot symmetry.

Results

As shown in **Figure 1**, our search strategy yielded 658 articles. After screening the abstracts, a total of 26 studies underwent further revision. Subsequently, 10 papers were excluded during full text review due to irrelevant outcome or unsuitable study design, while no extra studies were found during citations search of relevant articles. As a result, 16 studies consisting of 2 randomized controlled trials and 14 single-arm observational studies, with a total of 356 participants who underwent DMR were included.¹⁵⁻³⁰ Baseline characteristics of included studies and quality assessment are presented in **Supplementary Table S2** and **Supplementary Table S3**, respectively.

Outcomes

Technical success rate was reported in 5 studies, at 97% (95% CI: 33 to 100). Hydrothermal DMR had a technical success rate of 82% (95% CI: 0.64 to 0.92), whereas electroporation DMR was 100% (95% CI: 0.77 to 1.00), and radiofrequency DMR was 100% (95% CI: 0.87 to 1.00).

Pooled estimates of metabolic parameters are presented in **Table 1**. Over 24 months follow-up, DMR resulted in significant reduction in body weight (MD: -2.50 kg; 95% CI: -2.60 to -2.39) and FPG (MD: -2.01 mmol/L; 95% CI: -2.43 to -1.60) compared with pre-DMR values. In contrast, changes in HbA1c (MD: -0.19%; 95% CI: -0.59 to 0.21), C-peptide (MD: -0.12 nmol/L; 95% CI: -0.42 to 0.18), fasting insulin (MD: -2.55 pmol/L; 95% CI: -17.77 to 12.68), urine microalbumin (MD: -3.00 mg/L; 95% CI: -33.19 to 27.19) and HOMA-IR score (MD: -1.97; 95% CI: -4.77 to 0.83) were not statistically significant. Liver-related parameters, including liver enzymes, the Fibrosis-4 (FIB-4) index, and liver fat fraction, showed no significant changes: AST decreased by 4.87 U/L (95% CI: -15.66 to 5.93), ALT by 8.22 U/L (95% CI: -23.72 to 7.28), FIB-4 index by 0.35 (95% CI: -1.81 to 1.11), and liver fat fraction by 2.75% (95% CI: -10.24 to 4.73). Similarly, no significant differences were observed in lipid profiles, including total cholesterol (MD: -0.10 mmol/L; 95% CI: -0.93 to 0.72), triglycerides (MD: -0.48 mmol/L; 95% CI: -1.14 to 0.18), LDL-cholesterol (MD: -0.13 mmol/L; 95% CI: -0.58 to 0.32), and HDL-cholesterol (MD: 0.06 mmol/L; 95% CI: -0.26 to 0.38).

Table 1. Pooled Effects Estimates of Metabolic Parameters in Patients who Underwent Duodenal Mucosal Resurfacing.

Outcomes	Pop.	Baseline			End of study			Mean difference			
		k	Mean (95%CI)	I ²	k	Mean (95%CI)	I ²	k	MD (95%CI)	I ²	p value
BMI (kg/m ²)	All	3	30.11 (26.06, 34.78)	76.6%	3	26.47 (18.11, 38.69)	94.4%	3	-1.48 (-5.77, 2.81)	0.0%	0.276
Weight (kg)	All	7	87.83 (82.22, 93.83)	76.3%	5	86.72 (75.97, 98.98)	77.1%	8	-2.50 (-2.60, -2.39)	0.0%	< 0.001*
HbA1C (%)	All	9	8.26 (7.45, 9.17)	97.8%	6	7.54 (6.70, 8.49)	92.4%	9	-0.19 (-0.59, 0.21)	0.0%	0.306
	T2DM	8	8.56 (7.85, 9.33)	93.2%	5	7.83 (6.96, 8.81)	67.7%	8	-0.64 (-1.11, -0.16)	0.0%	0.016*
FPG (mmol/l)	All	4	10.39 (8.58, 12.58)	70.5%	4	8.40 (6.24, 11.31)	92.4%	3	-2.01 (-2.43, -1.60)	0.0%	0.002*
C-peptide (nmol/l)	All	3	0.72 (0.33, 1.58)	85.3%	3	0.63 (0.27, 1.47)	93.4%	3	-0.12 (-0.42, 0.18)	0.0%	0.229
Fasting insulin (pmol/l)	All	4	81.73 (76.78, 87.00)	34.8%	4	70.65 (38.68, 129.06)	78.4%	4	-2.55 (-17.77, 12.68)	0.0%	0.631
HOMA-IR	All	5	6.94 (5.52, 8.73)	39.5%	4	4.07 (1.61, 10.30)	89.0%	5	-1.97 (-4.77, 0.83)	0.0%	0.123
	T2DM	3	7.44 (4.29, 12.92)	59.5%	2	2.64 (0.02, 384.62)	85.1%	3	-3.93 (-6.78, -1.09)	0.0%	0.027*
Urine microalbumin (mg/l)	All	2	12.95 (0.0, 2343.34)	17.1%	2	7.32 (0.00, 20840.42)	88.4%	2	-3.00 (-33.19, 27.19)	0.0%	0.846
TG (mmol/l)	All	3	1.77 (1.00, 3.15)	74.2%	3	1.38 (0.47, 4.04)	78.4%	3	-0.48 (-1.14, 0.18)	0.0%	0.088
TC (mmol/l)	All	3	4.17 (3.29, 5.30)	50.7%	3	4.07 (2.71, 6.11)	93.3%	3	-0.10 (-0.93, 0.72)	0.0%	0.639
LDL (mmol/l)	All	3	2.28 (1.61, 3.21)	70.9%	3	2.17 (1.28, 3.70)	90.2%	3	-0.13 (-0.58, 0.32)	0.0%	0.344
HDL (mmol/l)	All	3	1.18 (0.98, 1.42)	68.4%	3	1.27 (1.00, 1.61)	45.7%	3	0.06 (-0.26, 0.38)	0.0%	0.489
AST (U/L)	All	3	31.52 (17.28, 57.49)	71.0%	2	32.95 (0.21, 5081.61)	94.2%	3	-4.87 (-15.66, 5.93)	0.0%	0.517

ALT (U/L)	All	3	38.13 (29.37, 49.51)	11.2%	2	40.57 (0.17, 9463.31)	95.3%	3	-8.22 (-23.72, 7.28)	0.0%	0.444
FIB-4	All	3	1.39 (0.87, 2.22)	94.5%	2	1.29 (1.10, 1.51)	0.0%	2	-0.35 (-1.81, 1.11)	0.0%	0.179
Liver fat fraction (%)	All	3	12.29 (2.92, 51.80)	90.5%	3	8.82 (0.79, 99.01)	95.6%	3	-2.75 (-10.24, 4.73)	0.0%	0.254

BMI, Body mass index; HbA1c, Hemoglobin A1c; FPG, Fasting plasma glucose; HOMA-IR, Homeostasis Model Assessment of Insulin Resistance; TG, Triglyceride; TC, Total cholesterol; LDL, Low-density lipoprotein; HDL, High-density lipoprotein; AST, Aspartate transaminase; ALT, Alanine transaminase; FIB-4, Fibrosis-4; CI, Confidence interval

*Statistical significance

For subgroup analysis limited to T2DM patients only, DMR resulted in significant reduction in weight, HbA1c (MD: -0.64%; 95% CI: -1.11 to -0.16), FPG, and HOMA-IR (MD: -3.93; 95% CI: -6.78 to -1.09). In non-alcoholic steatohepatitis (NASH) patients, HbA1c increased by 0.1% (95% CI: -0.78 to 0.98) while HOMA-IR score increased by 0.50 (95% CI: -6.41 to 7.41). In polycystic ovarian syndrome (PCOS) group, HOMA-IR score saw an insignificant reduction (MD: -0.70; 95% CI: -6.53 to 5.13). 59% (95% CI: 12 to 94) of patients remained off insulin at the end of the study (**Supplementary Table S4**).

Adverse events (AEs) were grouped into procedural-related AEs presented in **Table 2**. For procedural-related AEs, the total incidence reported were 39% across studies (95% CI: 7 to 84), most of which are mild. Serious adverse events occurred in 5% (95% CI: 1 to 24) of patients, namely, high fever requiring hospitalization, jejunal perforation, and hematochezia. Most common procedural-related AEs included hypoglycemia (15%), diarrhea (10%), nausea (9%), abdominal pain (5%), and vomiting (3%).

Table 2. Incidence Proportion of Adverse Events in Patients who Underwent Duodenal Mucosal Resurfacing.

Outcomes	DMR		
	k	Proportion (95% CI)	I ²
Procedural-related AEs			
-Total procedural-related AEs	5	0.39 (0.07, 0.84)	0.0%
-Serious AEs	4	0.05 (0.01, 0.24)	0.0%
-Abdominal pain	6	0.05 (0.00, 0.37)	0.0%
-Diarrhea	2	0.10 (0.00, 1.00)	86.0%
-Duodenal stenosis	2	0.06 (0.00, 0.93)	11.2%
-Hypoglycemic events	2	0.15 (0.00, 1.00)	83.7%
-Nausea	2	0.09 (0.00, 0.89)	42.7%
-Vomiting	2	0.03 (0.00, 0.98)	0.0%

DMR, Duodenal mucosal resurfacing; AEs, Adverse events; CI, Confidence interval

Post-DMR patient-reported satisfaction were investigated in 2 studies using the Diabetes Treatment Satisfaction Questionnaire, reporting as change and status scores. The mean status score was 33.15 (95% CI: 27.37 to 38.93), and mean change score was 12.39 (95% CI: 11.22 to 13.56) as shown in **Supplementary Table S5**.

Discussion

We present the first meta-analysis that systematically evaluates long-term durability of DMR in weight management and metabolic outcomes. This study demonstrates benefits in patients with diabetes, with an overall low serious adverse event rate and high patient-reported satisfaction. These findings outline the metabolic impact and safety profile of DMR.

Previous studies on DMR in T2DM patients found significant short-term improvement of glycemic parameters,³¹ this could be explained by post-DMR reduction of duodenal surface area, which is known to contain overexpressed glucose transporter and resulting in increased glucose absorption.³² Reducing duodenal surface area may result in less glucose absorption. The long-term beneficial effects of DMR on metabolic outcomes, on the other hand, appear to be mediated primarily by modulation of the enteroendocrine signaling pathway.

By reversing the hyperplastic duodenal mucosa in patients with T2DM, DMR restores the enteroendocrine cells that line the duodenum and regulate glucose homeostasis through hormones such as GLP-1 and GIP.^{33,34}

GLP-1 and GIP reduce hepatic fat accumulation, stimulate pancreatic beta cell function, and stimulate the gut-brain metabolic axis, all of which enhance peripheral insulin sensitivity.^{35,36} This allows for long-term improvement of insulin resistance, the main underlying pathophysiology in T2DM patients. Our pooled HbA1c reductions up to 24 months in a subgroup of T2DM patients undergoing DMR, with a parallel decrease in FPG levels, indicate durable improvement in glycemic control. While the absolute weight loss was modest (2.50 kg), the clinical significance of these metabolic improvements should be interpreted in the context of established evidence. The UKPDS 35 landmark study demonstrated that each 1% reduction in HbA1c was associated with a 21% reduction in diabetes-related endpoints and a 37% reduction in microvascular complications, with no lower threshold of benefit.⁴¹ The observed 0.64% HbA1c reduction in T2DM patients, while moderate, may therefore translate to meaningful long-term risk reduction. Our results also demonstrated improvement in insulin sensitization in T2DM patients through improvement of HOMA-IR score. These findings suggest that post-DMR glycemic improvements are driven primarily by direct modulation of metabolic signaling rather than weight loss alone, which may account for the disproportionate metabolic benefit relative to the modest weight reduction.

However, in a subgroup analysis, changes in HOMA-IR score were insignificant in NASH and PCOS subgroup but were significantly reduced in T2DM patients. This suggests that DMR efficacy might depend on pre-existing mucosal abnormalities (e.g., hyperplasia, insulin-desensitized phenotype) caused by chronic glycemic dysregulation].^{22,37} This highlights the need for future trials evaluating metabolic efficacy in different conditions, to determine which subgroups of patients would most likely benefit from DMR.

Liver-related parameters, including liver enzymes (AST and ALT), FIB-4 index, and liver fat fraction, did not improve in long-term follow-up. These findings contrast with a previous meta-analysis investigating short-term (3 to 6 months) effect of DMR on liver-related parameters, which found significant reduction in AST, ALT, and liver fat fraction.³⁸ Our results suggest that hepatic steatosis and inflammation may temporarily improve by early inhibition

of hepatic glucose production, but unlike glycemic profile, liver parameters require sustained and significant weight loss and metabolic control to achieve long-term effects. Evidence from bariatric and pharmacological trials suggest that weight loss of $\geq 10\%$ of total body weight is required for a significant resolution of NASH.^{39,40} In the absence of notable caloric restriction, the liver remains exposed to the altered metabolic environment, causing liver enzymes to revert to previous baseline, which likely explains why the overall result did not show significant improvement on liver function and fibrosis.

While most adverse events reported were mild, serious adverse events still occurred with a pooled rate of 5%. Cases of duodenal stenosis were reported in early first-in-human studies. Overlapping ablation and ablation of the non-lifted mucosa were mentioned as the culprit cause of duodenal stenosis.²⁸ As a result, refinement to the endoscopy and ablation protocol were made in subsequent studies, along with the ongoing learning curves, leading to fewer serious adverse events reported in more recent cohorts.^{25,30} Unlike conventional bariatric surgery, DMR has not shown long-term consequences like malabsorption. Other documented adverse events of DMR are mostly self-limited and short-lived, nevertheless, more studies with extended follow-up period post-DMR are still required to establish the long-term safety of the procedure.

Given these findings, the role of DMR within the broader landscape of metabolic interventions remains to be defined. While the modest weight loss observed with DMR is unlikely to match the magnitude achieved by gastric-restrictive EBMTs or conventional bariatric surgery, the metabolic improvements in T2DM patients, particularly in glycemic control and insulin resistance, suggest a potential niche for DMR as an adjunctive therapy in patients with insulin resistance who may not be candidates for, or who decline, more invasive procedures. Larger randomized trials with active comparators, cost-effectiveness analyses, and long-term real-world data are needed to optimally integrate DMR into clinical practice.

Our study has several important limitations. First, the included studies were predominantly single-arm observational studies, with only 2 randomized controlled trials. Without control groups in most studies, observed changes in outcomes cannot be definitively attributed to the DMR intervention itself, as concurrent medications, lifestyle modifications, and natural disease course may have contributed to the effects observed. Confounding factors should also be considered, as most included trials allowed for co-intervention with oral antidiabetic drugs and lifestyle counseling during the study period. Additionally, there was heterogeneity in the duration of follow-up across studies (ranging from 6 to 24 months) and in study population baseline characteristics. Despite these limitations, our meta-analysis integrates newer randomized trials and real-world data across various metabolic outcomes and different DMR techniques. Future randomized head-to-head comparisons to current standard of care with extended follow-up periods are warranted. Investigations should also aim to optimize DMR protocols including ablation length and process.

Over 24 months, modest but durable improvements in weight and glycemic outcomes were observed among patients who underwent DMR, with a favorable safety profile. However, the clinical significance of these improvements remains to be established through larger, randomized controlled trials. These findings suggest DMR warrants further investigation as a potential adjunctive option for metabolic disease management, particularly in patients with T2DM and insulin resistance.

Conclusion

Modest but durable improvements in weight loss and glycemic outcomes were observed among patients who underwent DMR across diverse settings, with a favorable safety profile. These findings suggest DMR warrants further investigation as an adjunctive option for metabolic disease management.

Abbreviations

AEs	Adverse events
ALT	Alanine aminotransferase
AST	Aspartate aminotransferase
BMI	Body mass index
CI	Confidence interval
DMR	Duodenal mucosal resurfacing
EBMT	Endoscopic bariatric and metabolic therapies
FIB-4	Fibrosis-4
FPG	Fasting plasma glucose
GIP	Glucose-dependent insulintropic polypeptide
GLP-1	Glucose-like peptide 1
HbA1c	Hemoglobin A1c
HDL	High-density lipoprotein
HOMA-IR	Homeostasis Model Assessment of Insulin Resistance
HR	Hazard ratio
IQR	Interquartile range
KG	Kilogram
L	Liter
LDL	Low-density lipoprotein
M	Meter
MG	Milligram
MMOL	Millimole
NASH	Non-alcoholic steatohepatitis
NMOL	Nanomole
OR	Odd ratio
PCOS	Polycystic ovarian syndrome
PMOL	Picomole
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
RR	Relative risk
RYGB	Roux-en-Y gastric bypass
SD	Standard deviation

T2DM	Type 2 Diabetes Mellitus
U	Unit

Declarations

Ethics approval:

Not applicable

Disclosures

Drs. Suangburanakul, Siranart, and Pajareya have no conflicts of interest or financial ties to disclose. Dr. Steinway is a consultant for Boston Scientific and Olympus and is a Scientific Advisor for Microvitality, Inc

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Author Contribution

N.S., P.P, and S.S. came up with the project idea. N.S., P.P, and S.S. Wrote the manuscript. N.S. and P.P prepared the figures. All authors reviewed the manuscript.

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Figures

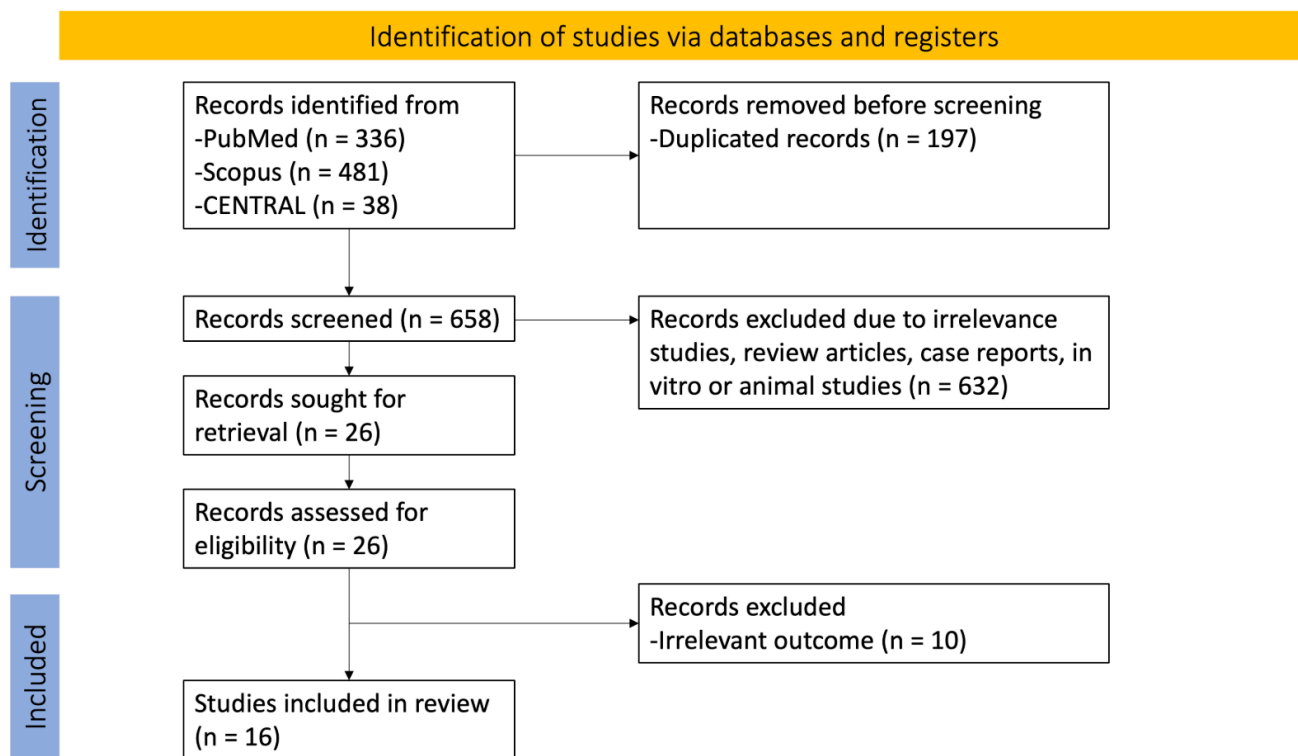


Figure 1

PRISMA Flow Diagram

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