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Review Article

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Metabolic Surgery in Korea

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ABSTRACT

Metabolic surgery (MS) is a surgery that focuses on improving obesity-related comorbidities. It is often referred to as "diabetic surgery" because of its focus on treating type 2 diabetes. MS is distinguished from bariatric surgery (BS), in which weight loss is the primary goal. However, from a broader perspective, all surgeries for obese patients with diabetes can be considered MS. In Korea, metabolic and bariatric surgery (MBS) has been covered by the national health insurance since 2019. Patients with a body mass index (BMI) ≥35 or those with a BMI ≥30 and obesity-related comorbidities were eligible for MBS. Simultaneously, MS for patients with BMI values between 27.5 and 30 was partly reimbursed. The two major metabolic surgeries are Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG). According to the registry of the Korean Society of Metabolic and Bariatric Surgery, 1,560 metabolic surgeries for obese patients with diabetes were performed between 2019 and 2021 in Korea, which was approximately 35.6% of all bariatric surgeries. SG was the most common, followed by RYGB and duodenal switch surgery. When dividing the patients with diabetes who underwent MBS into two groups, specifically those with BMI <35 and ≥35, we found that SG was performed most common procedure in both groups. However, there was a higher proportion of RYGB and duodenal switch operation in the former, indicating a difference in surgical methods between the two groups. MS is a promising tool for the management of poorly controlled diabetes. More data are needed to establish proper patient selection and choice of surgical type.

Keywords: Metabolic surgery; Diabetes mellitus; Gastrectomy; Gastric bypass; Obesity, morbid

INTRODUCTION

Bariatric surgery (BS) is considered the gold standard of treatment for morbid obesity [1,2]. In Korea, BS has been covered by national health insurance since 2019. The indication is a body mass index (BMI) same or higher than 35 kg/m^2 or a BMI same or higher than 30 kg/m^2 with obesity-related comorbidities, such as type 2 diabetes mellitus (T2DM), hypertension, or fatty liver disease.

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Metabolic surgery (MS) is a surgery that focuses on improving obesity-related comorbidities, of which T2DM is the most common and important [3]. The type of MS does not differ from that of BS. In Korea and many other countries, the most common procedures nowadays are sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) [4,5]. The mechanisms by which diabetes improves after MS can be divided into 2 main categories: 1) weight loss effects and 2) non-weight loss effects. Recently, there has been growing interest in the latter category, primarily driven by the question of the source of significant diabetes improvement that occurs immediately after MS, specifically the improvement that starts before any weight loss. This question is currently the subject of active research, and some of the proposed mechanisms of action include changes in the gut hormones such as glucagon-like peptide-1, changes in bile secretion and absorption, changes in the gut microbiome, and decreased toxicity of fat cells [6,7].

Pure MS refers to MS performed in non-obese patients with diabetes. Although not yet clearly defined, it can be referred to as surgery for patients with a BMI less than 30 kg/m^2 in East Asian countries, including Korea. Because the effect of MS is mainly related to body weight reduction after surgery, pure MS is generally considered less effective than MS in morbidly obese patients [8]. Therefore, several surgeons hesitate to perform pure MS, and data on pure MS remain very limited.

However, in Korea, pure MS can be performed as it is partly covered by the national health insurance. In 2018, one year before starting national insurance coverage for BS, patients with a BMI between 27.5 kg/m^2 and 30 kg/m^2 are indicated for MS. Herein, we aim to define MS and discuss the current status of MS in Korea, as well as the expected benefits for patients with T2DM.

DEFINITION OF MS: FOCUSING ON DIFFERENCES FROM BS

BS is progressively emerging as the standard treatment for morbid obesity unresponsive to medical treatment. However, following BS, not only does significant weight loss occurs, but several comorbidities related to obesity, such as T2DM, often show concurrent improvement. Recently, there has been an increasing number of cases in which the primary goal is to control T2DM through surgery, rather than focusing on weight loss. This is referred to as "metabolic surgery," which is distinguished from BS. It is sometimes referred to as "diabetic surgery" because of its focus on the treatment of diabetes.

Calculating the proportion of MS among all BS is not straightforward, because a considerable number of morbidly obese patients also have diabetes, and determining whether the purpose of surgery in these patients is weight loss, diabetes treatment, or a combination of both can be more challenging than expected. From the patient's perspective, they may experience a sense of guilt or shame regarding their morbid obesity. However, they do not typically experience the same feeling toward their diabetes; therefore, they desire the surgery they undergo to be MS. On the other hand, the perspective of a surgeon is somewhat diverse. however, it appears that they prefer to use the term 'bariatric surgery,' which has almost certain postoperative treatment effects, rather than the term 'metabolic surgery,' which has various postoperative treatment effects. Nevertheless, some surgeons with a strong academic interest in MS prefer to refer to their work as "metabolic surgery" whenever possible. From a broad perspective, surgery for all obese patients with diabetes can be considered as MS.

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CURRENT EVIDENCES OF MS

MS is an effective procedure that combines the characteristics of adequate and sustainable weight loss, which is the hallmark of bariatric surgery, with improvement of diabetes through a variety of mechanisms that may or may not be related to weight loss. Although concrete guidelines have not yet been established, data on comparable glycemic control continue to be published, and the traditional notion of indications for MS for those above a certain BMI is rapidly evolving.

After the publication of the first guidelines on the surgical treatment for T2DM in 2007 by the first Diabetes Surgery Summit (DSS-I), a revised set of guidelines was announced in 2015 by the second DSS (DSS-II). After the predominantly observational study-based DSS-I guidelines [9], the American Diabetes Association (ADA) and the International Diabetes Federation (IDF) gradually advanced the evidence [10,11], and in the DSS-II [12], meaningful conclusions were drawn based on important randomized controlled trial results (**Table 1**). The DSS-II guideline stated that MS: 1) should be a recommended option to treat T2DM in appropriate surgical candidates with class III obesity (BMI ≥40 kg/m^2), regardless of the level of glycemic control, as well as in patients with class II obesity (BMI 35.0–39.9 kg/m^2) with inadequately controlled hyperglycemia despite lifestyle and optimal medical therapy; 2) should also be considered to be an option to treat T2DM in patients with class I obesity (BMI 30.0–34.9 kg/m^2) and inadequately controlled hyperglycemia; and 3) all BMI thresholds should be reduced by 2.5 kg/m^2 for Asian patients.

Most importantly, the glycemic benefits of MS have been observed in patients with an initial BMI<35 kg/m^2. In the STAMPEDE trial, the antidiabetic effects of MS were the same in patients with preoperative BMIs higher or lower than 35 kg/m^2 [14,15,28]. The outcomes of pure MS in patients with BMI ≤30 have been reported in Taiwan and China. Lee et al. [8] in Taiwan reported a 25% complete remission rate and 60% diabetes improvement in 80 patients with type 2 diabetic and a BMI ≤30. Liang et al. [29] in China reported a 50% complete and partial remission rate in the same patient population. RYGB was reported to be effective in Indian patients with a baseline BMI of less than 35 kg/m^2 [30], and meta-analyses have also demonstrated similar BMI-independent benefits of MS [31,32]. As a result, the current guidelines support the use of MS in patients with class I obesity and poorly controlled T2DM [12], particularly, the 2022 American Society for Metabolic and Bariatric

Table 1. Randomized controlled trials on MS for patients with T2DM

Authors	Type of surgery	No. of patients	BMI indication (% of patients with < or ≤35)	Overall remission rate (P<0.05)	Remission criteria*	Follow-up (period, rate)
Dixon et al. [13]	LAGB vs. control	30 vs. 30	>30 and <40 (<35, 22%)	73% vs. 13%	HbA1c <6.2%	24 months, 92%
Schauer et al. [14,15]	RYGB vs. SG vs. control	50 vs. 50 vs. 50	≥27 and ≤43 (<35, 36%)	35% vs. 20% vs. 0	HbA1c ≤6.2%	36 months, 91%
Mingrone et al. [16,17]	RYGB vs. BPD vs. control	20 vs. 20 vs. 20	≥35	42% vs. 68% vs. 0	HbA1c ≤6.5%	60 months, 88%
Ikramuddin et al. [18,19]	RYGB vs. control	60 vs. 60	≥30 and <40 (<35, 59%)	25% vs. 0%	HbA1c ≤6.0%	24 months, 92%
Liang et al. [20]	RYGB vs. control vs. Exenatide	31 vs. 36 vs. 34	>28 and <35	90% vs. 0 vs. 0	No description	12 months, 100%
Halperin et al. [21]	RYGB vs. control	19 vs. 19	≥30 and ≤42 (<35, 34%)	58% vs. 16%	HbA1c <6.5%	12 months, 100%
Courcoulas et al. [22,23]	RYGB vs. LAGB vs. control	20 vs. 21 vs. 20	≥30 and ≤40 (<35, 43%)	40% vs. 29% vs. 0	HbA1c <6.5%	36 months, 85%
Wentworth et al. [24]	LAGB vs. control	25 vs. 26	≥25 and ≤30 (≤30, 100%)	52% vs. 8%	FBS <7.0 mmol/L	24 months, 92%
Parikh et al. [25]	Bariatric surgery (RYGB, LAGB, SG) vs. control	29 vs. 28	≥30 and ≤35 (≤35, 100%)	65% vs. 0	HbA1c <6.5%	6 months, 100%
Cummings et al. [26]	RYGB vs. control	23 vs. 20	≥30 and ≤45 (<35, 25%)	60% vs. 5.9%	HbA1c <6.0%	12 months, 74%
Mingrone et al. [27]	RYGB vs. BPD vs. control	20 vs. 20 vs. 20	≥35	25% vs. 50% vs. 0	HbA1c <6.5%	120 months, 95%

MS = metabolic surgery; T2DM = type 2 diabetes mellitus; BMI = body mass index; LAGB = laparoscopic adjustable gastric banding; HbA1c = glycated hemoglobin; RYGB = Roux-en-Y gastric bypass; sleeve gastrectomy; BPD = biliopancreatic diversion.
*Reaching HbA1c value without diabetes medication, unless otherwise specified.

Surgery/International Federation for the Surgery of Obesity and Metabolic Disorders guideline suggested that MS should be considered for patients with a BMI of 30–34.9 kg/m² and for Asian patients with a BMI ≥27.5 kg/m², indicating a downward revision of the BMI criteria [33].

CURRENT STATUS OF MS IN KOREA

1. MS in a broad definition (metabolic bariatric surgery [MBS] performed in morbidly obese patients with diabetes)

According to a national survey conducted by the Korean Society for Metabolic and Bariatric Surgery (KSMBS), the first MBS was performed in Korea in 2003 [5]. Since then, fewer than 100 procedures have been performed each year, and the number of cases has increased dramatically to approximately 1,700 in 2013, with the rise in gastric banding since 2009. However, along with the international decline in gastric banding, the number of domestic MBS procedures has gradually decreased to approximately 500–600 cases annually. However, since the National Health Insurance began covering MBS in 2019, the number of cases has sharply increased to almost 3,000 cases annually.

Since 2019, the KSMBS has conducted a registration program for MBS, targeting certified surgeons accredited by the KSMBS. From 2019 to 2021, 4,382 cases were registered in the registration program data, corresponding to 72% of the 6,714 MBS cases reported to the Health Insurance Review and Assessment Service during the same period. Of these, 1,560 cases were accompanied by T2DM, accounting for 35.6% of all the total number of MBS cases (**Fig. 1**). Based on this calculation, a maximum of 2,167 cases of MS in Korea were performed over 3 years, with an average of approximately 722 cases per year. In general, it can be predicted that the prevalence of diabetes will increase as BMI increases. However, as shown in **Fig. 1**, a lower rate of diabetes above BMI 35 kg/m² can be interpreted as a stronger trend for BS for BMI ≥35 kg/m² and a stronger trend for MS for BMI <35 kg/m².

When comparing patients enrolled in the KSMBS registry through 2021 and categorizing them into diabetic and non-diabetic groups, the diabetic group had a mean age of 41.1 years, a relatively higher proportion of male patients, and a slightly lower mean weight by 1.4 kg.

	DM (+)	DM (−)
No.	1,560	2,822
	(35.6%)	(64.4%)

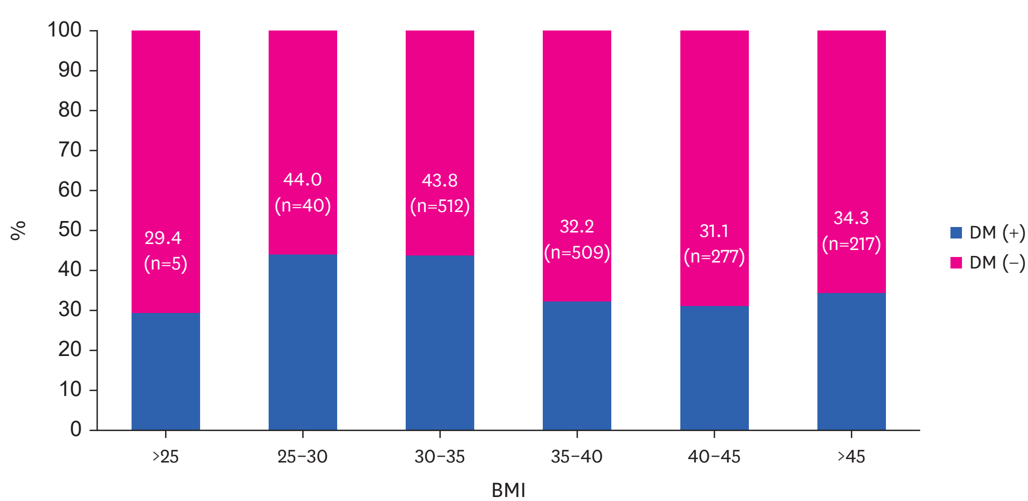

Fig. 1. Proportion of diabetes according to the body mass index (2019–2021).
DM = diabetes mellitus.

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Table 2. Comparison of demographics of DM vs. non-DM (2019–2021)

Characteristics	DM group	Non-DM group	P value
Cases	1,560 (35.6%)	2,822 (64.4%)	
Mean age (year)	41.1	35.7	<0.05
Sex (M:F)	1:2.0	1:2.8	
Mean body weight (kg)	105.9	107.3	<0.05
Mean BMI (kg/m^2)	38.3	39.0	<0.05
Operation method			<0.01
Sleeve gastrectomy	900 (57.7%)	2,360 (83.6%)	
Gastric bypass	387 (24.8%)	298 (10.6%)	
Sleeve-DJB	106 (6.8%)	17 (0.6%)	
Gastric banding	20 (1.3%)	32 (1.1%)	
Others (ex. Resectional bypass, Sleeve-PJB)	147 (9.4%)	115 (4.1%)	

The data in this table is for patients who had surgery in 2019-2021, and the data was collected in October 2022.
DM = diabetes mellitus; BMI = body mass index; DJB = duodenojejunal bypass; PJB = proximal jejunal bypass.

In terms of the operation type, the diabetic group had a lower proportion of SG (57.7% vs. 83.6%), a higher proportion of RYGB (24.8% vs. 10.6%), and a higher sleeve-duodenojejunal bypass (DJB) (6.8% vs. 0.6%; P<0.01) (**Table 2**).

2. MS with BMI less than 35 kg/m^2

Although the term "pure MS" was used to refer to surgeries performed on patients with diabetes who had a BMI less than 30 kg/m^2, the number of cases was not sufficiently large; therefore, we expanded the scope to compare MS cases in patients with diabetes who had a BMI <35 and cases with a BMI ≥35 kg/m^2. Similar to MS with a broad definition, SG was the most commonly performed procedure. However, its proportion was lower than that in the BMI ≥35 kg/m^2 group (49.1% vs. 60.1%; P<0.001). Conversely, the proportion of RYGB and sleeve-DJB was significantly higher in the BMI<35 kg/m^2 group (27.6% vs. 24.4%, 7.6% vs. 5.6%; P<0.05) (**Table 3**).

It is widely accepted that obese patients with diabetes respond well to MS. The surgeons use several prediction models to calculate the possibility of diabetes improvement after MS. The most widely used ABCD system predicts the degree of diabetes remission based on four factors: age, BMI, C-peptide level, and duration of diabetes [8]. However, the aforementioned non-weight-loss effects cannot be ignored. One factor that many physicians and surgeons have highlighted as an outcome of diabetes improvement, in addition to weight loss, is the ability of the pancreatic beta cells to secrete insulin. This indicates that, as long as there is some insulin secretion, peripheral insulin resistance can be lowered by performing MS, which can lead to diabetes control, regardless of weight loss. In clinical practice, MS may be considered in patients who are not morbidly obese, such as those with intractable diabetes irresponsive to medical therapy, those with ongoing diabetic complications, or those who continue to gain weight with insulin use. In these patients, remission is uncommon, and

Table 3. Metabolic surgery for BMI 35 kg/m^2 or less (2019–2020)

Operation method	All cases			DM cases		
	BMI <35	BMI ≥35	P value	BMI <35	BMI ≥35	P value
Sleeve gastrectomy	661 (65.9%)	1,879 (77.4%)	<0.001	219 (49.1%)	460 (60.1%)	<0.05
Gastric bypass	178 (17.8%)	350 (14.4%)		123 (27.6%)	187 (24.4%)	
Gastric banding	18 (1.8%)	27 (1.1%)		8 (1.8%)	9 (1.2%)	
Sleeve-DJB	38 (3.8%)	48 (2.0%)		34 (7.6%)	43 (5.6%)	
Others	108 (10.8%)	125 (5.1%)		62 (13.9%)	66 (8.6%)	
Total	1,003	2,429		446	765	

The data in this table is for patients who had surgery in 2019-2020, and the data was collected in September 2021.
BMI = body mass index; DM = diabetes mellitus; DJB = duodenojejunal bypass.

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improvement in the glycated hemoglobin (HbA1c) level is the most important therapeutic target, rather than discontinuing diabetes medication. Therefore, not only bariatric surgeons but also physicians are increasingly interested in the effects of MS in non-obese patients with diabetes. Because the surgical outcomes in non-obese patients with diabetes are somewhat inferior to those in obese patients with diabetes, it is crucial to make proper patient selection and provide the most appropriate surgery to the patient at the right time.

3. MS with BMI less than 30 kg/m^2

Recognizing the clinical importance of MS for these non-obese patients with diabetes, the Korean government first recognized "pure MS" for T2DM with a BMI of 27.5 kg/m^2 or more who are refractory to medical treatment as a new medical technology in 2018, and since January 2019, MS for patients with a BMI between 27.5 kg/m^2 and 30 kg/m^2 has been covered by partial national health insurance (80% patient contribution). According to the KSMBS registry data, among 1,398 registered cases of MBS in 2019, 475 were accompanied by diabetes, indicating that approximately 34% of MBS cases in Korea have an MS component, which is similar to the previously reported ratio of 35.6%. SG was performed in 74% of all MBS cases and RYGB in 15.4%. In contrast, in the MS group, SG and RYGB accounted for 59% and 29.9%, respectively, indicating that RYGB was performed more frequently. Among the patients with diabetes and a BMI of less than 30, a total of 23 patients, accounting for 4.8% of MS, were identified. The patients were relatively older, with an average age of 47.3 years, with a higher proportion of RYGB (34.8%), no banding procedure, and a relatively higher proportion of sleeve-DJB (8.7%) (**Fig. 2**).

In 2019, 23 pure MS were registered with the KSMBS in Korea, representing approximately 5% of the 475 registered MS. Of the 19 cases for which more detailed clinical outcomes were available, all but four cases had preoperative ABCD scores of 4 or less, indicating a very low likelihood of diabetes remission. The postoperative outcomes of these patients up to one year, showed that in all but five cases, the number of diabetes medications could be reduced, and in all but two cases, the HbA1c level could be lowered to 7.0% or less. Several multicenter

Characteristics		All cases (n=1,398)	DM cases (n=475)	DM & BMI <30 (n=23)
Mean age (year)		37.8	41.1	47.3
Sex	Male	477 (34.1)	176 (37.1%)	6 (26.1%)
	Female	921 (65.9)	299 (62.9%)	17 (73.9%)
Mean body weight (kg)		109.3	107.3	75.6
Mean BMI (kg/m^2)		39.3	38.5	28.2
Operation method	Sleeve gastrectomy	1,035 (74.0%)	280 (58.9%)	13 (56.5%)
	Gastric bypass	215 (15.4%)	142 (29.9%)	8 (34.8%)
	Gastric banding	58 (4.1%)	5 (1.1%)	-
	Sleeve-DJB	10 (0.7%)	7 (1.5%)	2 (8.7%)
	Others	78 (5.6%)	41 (8.6%)	-

34% 4.8%

Fig. 2. Comparison of the characteristics and operation types of patients who underwent bariatric, metabolic, and pure metabolic surgery (2019).
The data in this figure is for patients who had surgery in 2019, and the data was collected in August 2020.
DM = diabetes mellitus; BMI = body mass index.

long-term follow-up studies are underway in Korea, and the conclusions of the analysis of MS outcomes in patients with T2DM and obesity conducted by the National Evidence-based Healthcare Collaborating Agency will be particularly noteworthy.

CONCLUSION

MS is no longer a surgery that only surgeons claim to be superior. The IDF, an organization of endocrinologists, also recommends MS as a treatment for patients with T2DM who are morbidly obese with BMI ≥30 or 35. The mechanism by which MS cures diabetes is thought to be primarily a secondary effect of weight loss; however, there appear to be several other mechanisms.

More recently, the value of MS has been recognized in patients with T2DM who have a BMI <30 and are unresponsive to medical therapy. However, in these non-obese patients with diabetes, the improvement in diabetes is generally lower than that in obese patients with diabetes; therefore, it is expected that the effectiveness of treatment can be improved by actively engaging in multidisciplinary collaboration between physicians and surgeons before surgery to determine the indications, timing, and types of surgery.

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