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Original research

The two different biliopancreatic limb lengths for roux-en-Y gastric bypass

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ABSTRACT

Background: Bariatric surgery is the most obvious way of treatment for morbid obesity and Roux-en-y Gastric Bypass (RYGB) is the most well-known technique. Meta-analysis results about the effects of Biliopancreatic limb length (BPLL) on weight loss and metabolic factors in blood remained controversial. This study aims to evaluate two different BPLL outcomes in obese patients.

Methods: This retrospective cross-sectional study conducted on 64 obese patients who had RYGB indications in 2017. Small intestine bypassed length was 180 cm for all patients with a 40-mililitter gastric pouch. BPLL was chosen to be 130-cm in one group and 50-cm in another one. The Roux limb had the opposite length. Demographic data and metabolic factors assessed preoperatively and frequently evaluated in 1, 3, 6, and 12 months postoperatively.

Results: Both methods were successful in promoting significant weight loss, however, 130-cm BPLL had significantly higher excess weight loss. Blood glucose index, lipid profile, albumin, and blood pressure were also reduced significantly in both groups during the follow-ups (P-value < 0.001). Serum iron increased significantly in 130-cm BPLL group.

Conclusion: Both short and long BPLL caused effective weight loss in non-super obese patients. Longer BPLL caused faster weight loss without any significant differences in metabolic factors.

1. Introduction

Morbid obesity has become a challenging health issue in both developing and developed countries. This condition has occurred due to sedentary life style with less physical activity, and consuming more high-caloric foods. Morbid obesity, known as body mass index (BMI) $>$ 40 kg/m^2, involves almost all of the body systems and is accompanied with considerable adverse effects and comorbidities (Abdeen and Roux, 2016; Guh et al., 2009).

Recently, bariatric surgery is one of the most successful methods of losing weight. This technique achieves persistent weight loss, modulation of obesity comorbidities, quality of life promotion, and increased longevity by interfering to the normal gastrointestinal physiology (Buchwald et al., 2004).

Mason has invented Roux-en-Y Gastric Bypass (RYGB) surgery in 1960s (Mason and Ito, 1969). Most of the patients lost 70–80% of their excess weight in the following first and second year after the RYGB surgery. However, it has been reported that occasionally, patients with severe obesity have chances of weight regain (Nergaard et al., 2014). RYGB composes of two limbs, an alimentary or Roux limb, which is attached to the gastric pouch with an end-to-side anastomosis and Biliopancreatic limb (BPL), which is the duodenum and a different segment of the jejunum attaching to the alimentary limb just before common channel.

Although different studies have evaluated various alimentary limb lengths from 45 to 250 cm, they did not achieve a unanimous opinion in small intestine bypass length and this area remains to be controversial due to multifactorial etiologies (Nergaard et al., 2014).

Studies have shown that BPL elongation can cause more weight loss while it can cause more severe malnutrition than elongating alimentary limb due to eliminating the common channel length, which is the main part of absorption (Nergaard et al., 2014). Regarding what was mentioned above, little studies have been conducted to assess the role of different alimentary and BPLL on a trend of weight loss, weight

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regaining and malnutrition occurrence following RYGB surgery (Abdeen and Roux, 2016; Valezi et al., 2014; Sarhan et al., 2011; Choban and Flancbaum, 2002; Pentin and Nashelsky, 2005). Nergaard et al. evaluated long alimentary vs. long BPL with 210 cm and 260 cm bypassed intestine respectively. Common channel length in their study was undoubtedly shorter in the second group (Nergaard et al., 2014).

Therefore, current study has been conducted to compare the 130 vs. 50 cm of BPL outcomes in RYGB in morbid obese patients.

2. Methods

For this retrospective cross-sectional study, we evaluated eligibility of 70 patients who had indications of bariatric surgery (BMI > 40 kg/m^2 or BMI > 35 kg/m^2 with any comorbidities) and were referred to our hospital in 2017. RYGB with both methods for BPLL (130 vs. 50 cm) are valid in our center; therefore, all patients were matched by their age and sex and randomly allocated in both groups by simple randomization. Six patients were excluded due to missing data in follow-up results. Prophylactic antibiotic and antithrombotic therapy were prescribed for all of the patients. An informed written consent was obtained from all patients before the surgery. All of the surgeries were performed by a single laparoscopic surgeon and an attending physician. Small intestine bypassed length was 180 cm for all patients. Our patients were divided into two groups according to their different BPL length; 130 vs. 50 cm. The gastric pouch formed to be 40-mililitter in volume for all of the patients [Fig. 1].

Demographic (age, gender, weight, BMI) and preoperative lab data (fasting blood sugar (FBS), Hemoglobin A1C (HbA1C), triglycerides (TG), cholesterol (Chol), serum Iron (Fe), 25-OH vitamin D (VitD), vitamin B12 (VitB12), albumin (Alb), and blood pressure (BP)) of all patients were recorded in a checklist. For lab tests, 5 ml-blood samples were obtained and sent to our Hospital Laboratory Center for all patients.

In the following day, patients were recommended to initiate oral therapy by 30 ml soft liquid and their drain pulled-out in case of not having any leakage or discharge. Patients were discharged within 48 h after the surgery.

We followed our patients in 1, 3, 6, and 12 months after the RYGB surgery by assessing their body weight, blood samples and asking for any complaints or complication.

Obtained information was analyzed by IBM SPSS software version 20.0 (United States, Chicago). Descriptive data were reported in mean, standard deviation, and percentage. Independent *t*-Test, paired *t*-Test and ANOVA were used for further interpretations. P-value < 0.05 was considered significant. This study commenced after receiving its ethical approval from department of medical research ethics of our university.

3. Results

Table 1 is indicating the exact results of different BPLLs in RYGB. None of our patients had super obesity criteria (BMI > 50 kg/m^2). Patients were allocated equally in both groups by their age (39.82 ± 1.75 years in 130-cm BPLL and 40.21 ± 0.67 years in 50-cm BPLL group) and sex (16 male and 16 female in each group).

Although BMI had no significant differences between two methods in each follow-up time, both limb lengths made significant decrease in BMI after 1 year (P value < 0.001). Excess weight loss percentage increased over time postoperatively however, 130 cm BPLL had faster weight loss rate after 6 and 12 months (P value < 0.001).

FBS decreased in both groups over time, however, it showed a

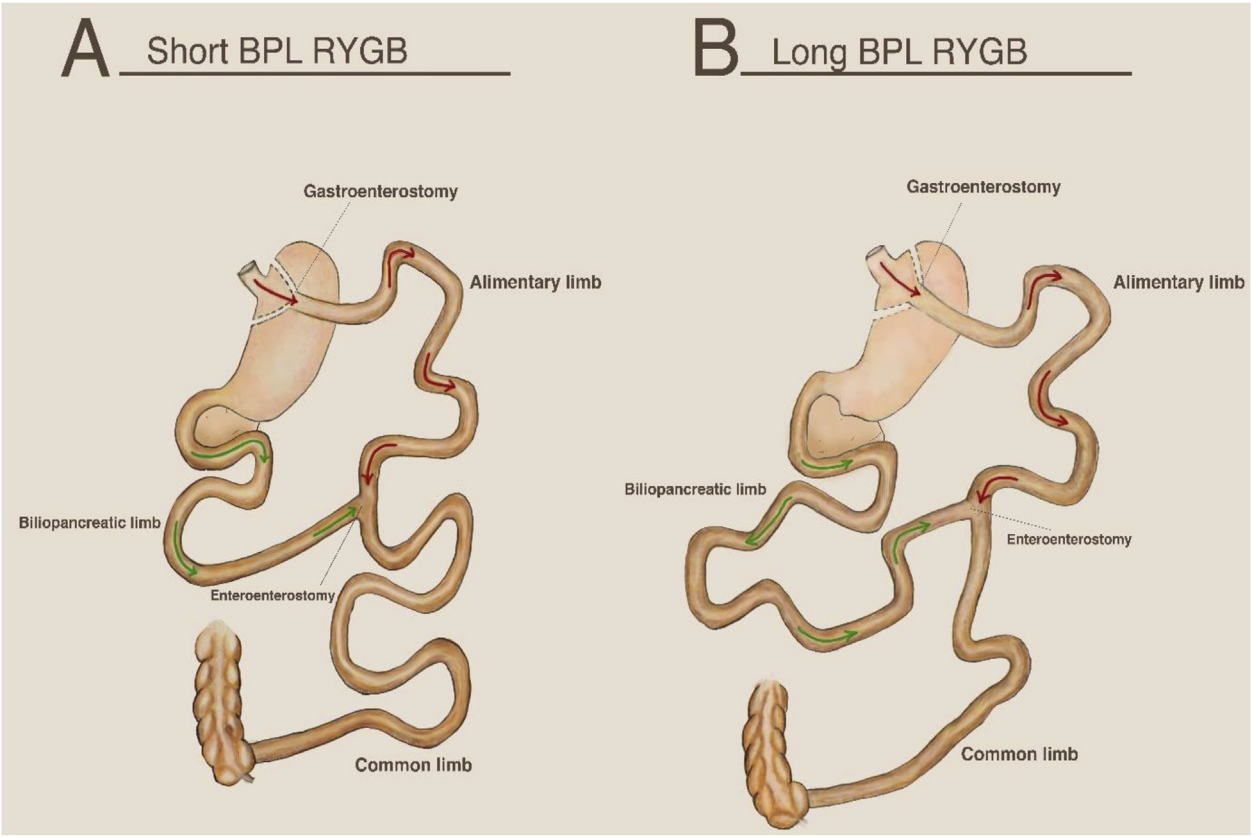

Fig. 1. gastrointestinal tract changes in Roux-en Y gastric bypass (RYGB) with small gastric pouch (40 mL) and two different biliopancreatic limb (BPL) lengths. **A.** short BPL (50 cm) and long Roux (alimentary) limb (130 cm). **B.** long BPL (130 cm) and short Roux limb (50 cm). Red arrows indicating the food pathway and green arrows indicating the gastric and biliopancreatic secretions. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 1
comparison of each variable in time between two different BPLLs.

Variables (mean ± SD)		BPLL		P value
		Long (130 cm) (n = 32)	Short (50 cm) (n = 32)	
FBS	**Before**	105.93 ± 14.88	99.86 ± 6.86	0.28
	1 month	92.56 ± 5.41	89.81 ± 3.44	0.01*
	3 months	88.84 ± 4.16	90.03 ± 1.78	0.25
	6 months	87.75 ± 4.56	89.59 ± 4.93	0.03*
	1 year	86.87 ± 3.94	88.62 ± 1.28	0.35
P value$		< 0.001*	< 0.001*	–
HbA1C	**Before**	6.55 ± 0.75	6.59 ± 0.55	0.44
	1 month	6.45 ± 0.7	6.53 ± 0.51	0.24
	3 months	5.94 ± 0.32	6.01 ± 0.24	0.31
	6 months	5.86 ± 0.54	5.71 ± 0.19	0.19
	1 year	5.71 ± 0.15	5.69 ± 0.12	0.80
P value$		< 0.001*	< 0.001*	–
TG	**Before**	277.71 ± 35.38	282.56 ± 41.52	0.61
	1 month	202.15 ± 16.09	201.81 ± 12.47	0.92
	3 months	173.53 ± 14.16	178.00 ± 10.78	0.16
	6 months	154.41 ± 11.38	155.87 ± 8.05	0.55
	1 year	142.31 ± 8.31	140.25 ± 8.15	0.32
P value$		< 0.001*	< 0.001*	–
Chol	**Before**	223.25 ± 23.39	219.40 ± 16.85	0.09
	1 month	185.18 ± 20.63	180.90 ± 12.23	0.31
	3 months	161.31 ± 174	159.34 ± 9.85	0.58
	6 months	145.87 ± 13.70	142.37 ± 9.50	0.24
	1 year	134.90 ± 8.91	132.43 ± 6.10	0.20
P value$		< 0.001*	< 0.001*	–
Fe	**Before**	56.12 ± 15.88	55.71 ± 15.55	0.71
	1 month	52.06 ± 16.20	51.75 ± 15.41	0.86
	3 months	52.12 ± 17.28	49.56 ± 13.73	0.41
	6 months	54.68 ± 18.36	52.53 ± 15.75	0.35
	1 year	65.50 ± 17.97	55.78 ± 13.97	0.86
P value$		< 0.001*	0.5	–
Ca (mg/dl)	**Before**	8.95 ± 0.48	9.24 ± 0.35	0.05
	1 month	8.80 ± 0.37	9.04 ± 0.29	0.0001*
	3 months	8.85 ± 0.21	8.94 ± 0.22	0.04*
	6 months	8.93 ± 0.25	8.85 ± 0.26	0.01*
	1 year	9.09 ± 0.29	9.00 ± 0.21	0.86
P value$		0.34	0.56	–
Vit D	**Before**	38.81 ± 5.77	38.87 ± 5.16	0.98
	1 month	38.41 ± 5.45	39.15 ± 5.53	0.58
	3 months	38.87 ± 5.79	40.56 ± 3.71	0.17
	6 months	39.75 ± 3.72	41.65 ± 3.16	0.03*
	1 year	39.30 ± 7.48	43.50 ± 3.32	0.005*
P value$		0.89	0.001*	–
Alb	**Before**	3.92 ± 0.12	3.92 ± 0.14	0.83
	1 month	3.52 ± 0.14	3.43 ± 0.26	0.001*
	3 months	3.59 ± 0.13	3.54 ± 0.16	0.32
	6 months	3.71 ± 0.12	3.67 ± 0.07	0.08
	1 year	3.70 ± 0.09	3.66 ± 0.07	0.19
P value$		< 0.001*	< 0.001*	–
Vit B12	**Before**	109.72 ± 34.97	117.37 ± 9.80	0.5
	1 month	112.12 ± 12.38	118.75 ± 9.21	0.01*
	3 months	114.59 ± 12.90	117.81 ± 8.66	0.24
	6 months	117.75 ± 12.79	123.71 ± 7.74	0.02*
	1 year	118.46 ± 15.45	126.56 ± 8.91	0.01*
P value$		0.2	0.81	–
BMI (kg/m^2)	**Before**	45.37 ± 3.56	45.16 ± 2.66	0.79
	1 month	41.61 ± 3.18	42.08 ± 6.63	0.71
	3 months	37.78 ± 3.02	37.88 ± 2.29	0.87
	6 months	33.07 ± 2.72	34.11 ± 2.21	0.09
	1 year	27.03 ± 2.93	29.57 ± 2.56	0.09
P value$		< 0.001*	< 0.001*	–
Excess Weight loss (%)	**1 month**	10.43 ± 1.66	10.12 ± 1.35	0.47
	3 months	20.81 ± 2.42	18.93 ± 2.13	0.2
	6 months	34.00 ± 3.34	29.40 ± 2.66	< 0.001*
	1 year	51.06 ± 6.02	41.06 ± 4.67	< 0.001*
SBP (mmHg)	**Before**	130.93 ± 10.95	126.65 ± 23.94	0.48
	1 month	116.09 ± 8.86	115.93 ± 7.87	0.88
	3 months	110.46 ± 8.82	105.93 ± 7.12	0.03*
	6 months	106.25 ± 7.93	102.81 ± 4.56	0.87
	1 year	104.37 ± 7.15	104.37 ± 5.04	0.59
P value$		< 0.001*	< 0.001*	–
DBP (mmHg)	**Before**	78.90 ± 3.96	76.71 ± 5.62	0.13
	1 month	72.34 ± 3.80	71.40 ± 2.61	0.42
	3 months	71.09 ± 2.10	70.31 ± 1.22	0.07
	6 months	71.25 ± 3.36	70.62 ± 1.68	0.45
	1 year	69.53 ± 2.94	67.65 ± 3.10	0.06
P value$		< 0.001*	< 0.001*	–

BPLL; Biliopancreatic limb length, SD; standard deviation, N; number of patients, FBS; fasting blood sugar, HbA1c; glycosylated hemoglobin A1, TG; Triglyceride, Chol; Cholesterol, Fe; Iron, Ca; Calcium, VitD D; Vitamin D, VitB12; Vitamin B12, Alb; Albumin, BMI; body mass index, SBP; systolic blood pressure, DBP; diastolic blood pressure.
*Is indicating significant P values (< 0.05).
P value: Between two groups in a specific time.
P value$: Intergroup (comparing before and after 1 year results).

plateau level ultimately. Both methods decreased FBS significantly after 1 year (P < 0.001). Despite the effects of both methods on HbA1C, neither method made any significant changes over time between the two groups. Lipid profile parameters (TG and Chol) decreased over time in both groups significantly; conversely, no significant differences revealed between the two groups. Both calcium and iron showed a U-like shape change in both groups. Nevertheless, iron level did not show significant difference between two groups. Calcium level was significantly higher in-group with 50 cm BPLL. This finding occurred before reaching the one-year postoperative follow-up.

Albumin level had a negative slope after 1 month in which 50 cm BPLL had a significantly lower concentration although its level increased and plateaued one year after the surgery. Compared to the preoperative results, both methods made the albumin to have a significantly lower and a more steady state after one year (P < 0.001).

Vitamin D differences between two groups increased over time in which 50 cm BPLL showed a higher value and these differences become significant at 6 and 12 months after the surgery (P value: 0.03 and 0.005 respectively). Overall comparison of preoperative and one-year follow-up results revealed vitamin D level changed significantly in 50 cm BPLL group (P value: 0.001).

BPL with 50 cm length had significantly higher levels of Vitamin B12 over time except after 3 months (P value: 0.24).

Mean systolic and diastolic blood pressure decreased significantly in both groups (P value < 0.001).

4. Discussion

Morbid obesity, a condition with increased prevalence worldwide, has significant consequences on quality of life and survival in a negative manner. These comorbidities include type-2 diabetes mellitus (DM2), Hypertension, Osteoarthritis, increased risk of Cancers and Cardiovascular episodes, isolation from society, loss of self-esteem and Depression. These facts have made morbid-obesity an important health care issue for communities and pose notable burden on health care systems (Nannipieri et al., 2013; Schauer et al., 2017). Bariatric surgery such as RYGB is of the most common and effective techniques used routinely to treat this condition. There are some issues in evaluating RYGB outcomes including trends of weight loss, weight regain, metabolic factors and nutritional changes postoperatively. Researchers hypothesized that these factors are associated with different biliopancreatic and alimentary limbs lengths (Nora et al., 2017). In this study, we tried to evaluate two valid and different BPLL outcomes in RYGB after 1 year postoperatively. Four follow-up times in 3-month intervals designed for all of the patients.

Both lengths acted the same and caused significant BMI decrease

after one year. However, excess weight loss was significantly higher in 130-cm BPLL group.

While mean value of FBS was in range of impaired fasting glucose, both groups showed significantly better glycemic state during the year after RYGB. Conversely, according to the HbA1C level, both groups were in range of diabetes mellitus while within a year their HbA1C changed significantly to a better state. Therefore, both methods were effective in decreasing and controlling blood glucose. A similar trend happened for lipid profile (TG and TC) as well and both procedures worked the same. It shows that BPLL did not affect the lipid profile significantly. Both limb lengths act the same on calcium and iron level however, 130-cm BPLL increased the level of iron 1 year after the surgery but calcium had a different response. 50-cm BPLL made a higher calcium levels than 130-cm over time. Vitamin D increased after one year of surgery in both groups however, 50-cm BPLL had significant higher level of it. Vitamin B12, which is an indicator of terminal ileum absorption state, increased over time nevertheless, 50-cm BPLL group had significantly higher concentration. Albumin is another indicator of nutritional state. Albumin is produced by liver therefore, its sufficient level can show the proper function of hepatocytes (Nergaard et al., 2014). Both groups had significant decrease in albumin levels in the following year after RYGB. Although its final levels were not in abnormal range, this shows the importance of required nutrition support for patients postoperatively. Both systolic and diastolic blood pressure decreased significantly and continuously in both methods postoperatively.

Nergaard et al. used two different types of limb length in their study: 2-m BPL with 60-cm alimentary limb and 60-cm BPL with 150-cm alimentary limb, which was entirely different from our protocol. They bypassed longer intestine and left shorter common channel than what we did (180-cm). They found that longer BPL act efficiently in weight loss and can prevent from weight regain in longer follow-ups. Their study revealed that common channels were more than 3-m in most of their patients and believe better weight loss outcomes is due to physiologic and hormonal changes of the intestine and not the short common channel length. Micronutrients are absorbed proximally. Therefore, calcium and iron supplementation was much more needed in the 2-m BPL group (Abdeen and Roux, 2016; Nergaard et al., 2014; Navez et al., 2016). They recommended long BPL method for higher, faster and longer weight loss with precise postoperative follow-ups to adjust the amount of supplementation for nutritional deficiencies and finding further complications (Nergaard et al., 2014). Mahawar et al. systematic review suggested optimum results achieved in 100–200 cm of BPL or Roux limb in most of the patients (Mahawar et al., 2016).

According to our study, both short and long BPLs decreased BMI significantly. However, long BPL group achieved higher EWL% than short BPL group within one year after the surgery. Iron level increased significantly after one year in our patients with 130-cm BPL however, patients with 50-cm BPL did not show any significant changes in iron level during the follow-ups. Calcium level showed an approximately steady level during the first year after the surgery in both groups. Vitamin D level had an increasing slope in 50-cm BPL group within one year after the surgery, in contrast to plateau level of it in 130-cm BPL group. Vitamin B12 increased slightly postoperatively in both groups as well, however, 50-cm BPL had significantly higher amounts of it. Albumin level was always above the normal level in both groups, which indicated that common channel length was sufficient in our patients as well. Therefore, according to our postoperative results, chances of nutritional deficiencies were much lower in our patients with successful continuous weight loss.

Dogan et al. increased Roux limb from 100-cm to 150-cm. Their 730 patients did not show significant difference in weight loss. However, both methods had low postoperative complications (Dogan et al., 2017).

One anastomosis gastric bypass or mini-gastric bypass is composed of a variable BPL. Lee et al. say the higher the length of BPL, the more weight loss the patient get (Lee et al., 2005, 2008).

Brolin et al. evaluated the long Roux limb (at least 150-cm) in super obese patients (BMI > 50 kg/m^2) and achieved more weight loss in this group. Patients with lower BMI do not benefit from long Roux limb procedure. Metabolic and nutritional deficiencies are depended on the common channel left, which become crucial to measure in very long Roux or BPL limb procedure (Brolin, 2005). Ciovica et al. reached the same results in their prospective study on 137 super obese patients (Ciovica et al., 2008).

Pinheiro et al. evaluated very long Roux limb (250-cm) with 100-cm BPL and 150-cm Roux limb with 50-cm BPL for super obese patients with DM2. They concluded that longer BPL and Roux limb together were more successful for DM2 control, lipid profile reduction and faster losing their excess weight (Pinheiro et al., 2008). According to the Orci et al. meta-analysis of eight studies, long Roux limb showed efficient outcomes for super obese patients. However, they regret that the results were heterogeneous and the overall quality was questionable. Therefore, not only this subject remains controversial, but also the results in non-super obese patients have to be evaluated as well (Orci et al., 2011).

Homan et al. randomized clinical study evaluated 150-cm and 75-cm BPL on 146 patients. After 1-year follow-up, they achieved the same results as others in excess weight loss. However, total weight loss was not significant between their groups. They did not reveal any changes in blood metabolic factors (Homan et al., 2018).

Buchwald et al. revised some cases of RYGB with complications and found out that higher BPL was accompanied with better weight loss and BMI control. However, nutritional and supplemental deficiencies in this group caused them to perform the revisional surgery (Buchwald and Oien, 2017).

In comparison to our study, none of our patients was categorized as super obese. Our long Roux limb group was 130-cm versus 50-cm biliopancreatic limb and it was concluded that for BMI and blood pressure reduction, glycemic control, lipid profile control and nutrient absorption, they work efficiently the same. The only significant point was excess weight loss percentage, which was higher in long BPL (short Roux) group. In contrast to calcium, iron level increased in 130-cm BPL group. In addition, vitamin B12 was significantly higher in 50-cm BPL group, however, significant increase in body vitamin D level observed in 50-cm BPL group.

In fact, close and regular postoperative follow-ups with adequate nutritional supplementation and laboratory check-ups are the crucial part for the bariatric surgery success rate besides the method of surgery.

5. Conclusion

RYGB is accompanied with acceptable weight loss, BMI and metabolic factors improvement regardless of its BPLL. Both long and short BPLL affect blood glucose, lipid profile, and blood pressure the same. Our results support that long BPLL is effective for non-super obese patients as well. Postoperative nutritional support is necessary for almost all of the patients and regular follow-ups can help detecting complications.

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Ethics statement

This study commenced after receiving its approval from department of medical ethics in research of our university. An informed written consent was taken from all of the patients before surgery.

Data availability statement

All of the data will be available for secondary analysis in necessary cases from the corresponding author through email address.

Declaration of competing interest

The authors declare no potential conflict of interests.

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