



# New Anchoring Mechanism and Design of an Endoluminal Duodeno-Jejunal Bypass Liner for Treatment of Obesity: a Pilot Animal Trial

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## Abstract

**Objective** Complications of bleeding, liver abscess and movement have been associated with previous duodeno-jejunal bypass liner (DJBL) applications in the past. A new anchoring system and design of a DJBL is presented as a pilot study.

**Method** A newly designed DJBL device was inserted in 2 pigs and observed over 2 months.

**Results** The newly designed device was anchored and monitored for 1 month in 1 of 2 pigs, the other being passed early. Effectiveness and safety have been shown.

**Conclusion** The results of this pilot study warrant further investigation of the modified DJBL setup, which may help solve standing issues associated with the clinical use of a DJB liner.

**Keywords** DJB liner · Anchoring system · Pilot study

## Introduction

Presently, bariatric surgery is the most effective method of achieving sustained weight loss compared to pharmacological or lifestyle interventions, but is invasive and therefore maybe unavailable to many patients [1, 2].

Parallel to the ongoing drug development efforts, other less-invasive treatment options have emerged. One of such technologies is the EndoBarrier™ a single-use endoluminal duodeno-jejunal bypass liner (DJBL) by GI Dynamics Inc., Lexington, MA, USA. Designed for obesity and T2DM management, EndoBarrier™ is an implantable medical device in the form of a 60 cm impermeable fluoropolymer sleeve liner

fitted with a delivery/retrieval system, which is placed endoscopically via the mouth and anchored in the first part of the small bowel (duodenum). In a recent review, Ruban et al. covered effectiveness, safety and possible modes of action of EndoBarrier™ [3].

Several studies investigated the effectiveness of EndoBarrier™. According to Ruban et al., a total of 5 randomised controlled trials (RCTs) were done to date, showing varying degrees of improvement in BMI, glycaemic control and other associated parameters such as arterial pressure and cholesterol levels [3–8].

A recent meta-analysis of 17 studies in total showed that at explantation, compared to control subjects, DJBL subjects had reductions in HbA<sub>1c</sub> by 1.3%, homeostatic model assessment of insulin resistance (HOMA-IR) scores by 4.6%, lost 11.3 kg in weight and corresponding 4.1 kg/m<sup>2</sup> in BMI. Weight loss remained significant 1 year post-explantation and HbA<sub>1c</sub> remained lower than baseline by 0.9% at 6 months post-explantation [9].

The two main challenges faced with the DJBL use are associated with complications and loss of beneficial effects on weight and glycaemic control post-explantation. Some of the reported complications, often causing premature device removal [10], include abdominal pain and nausea (usually resolvable in 98% of patients), GI bleeding (1.5% of patients), device migration (1.4%), obstructions, dislocation and liver

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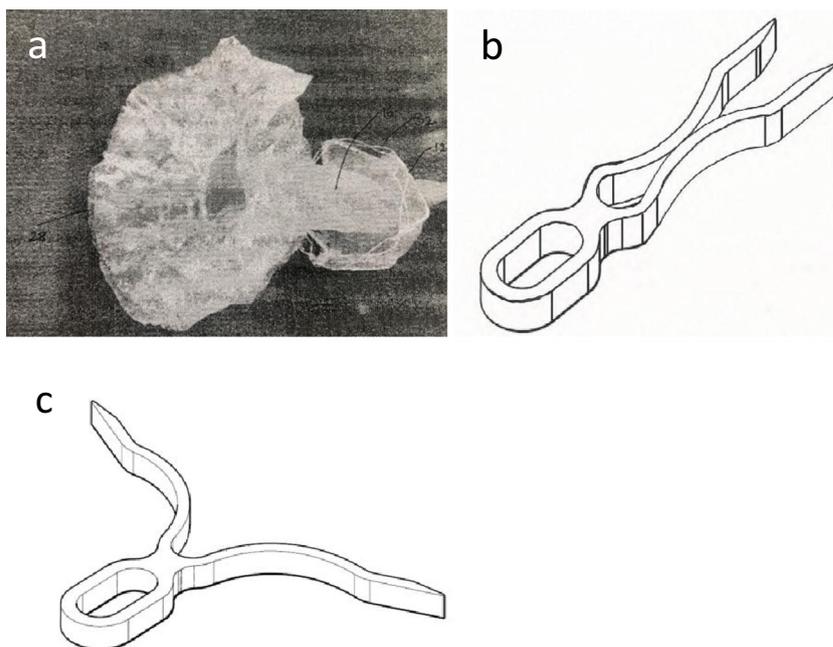
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**Fig. 1** Duodeno-jejunal bypass liner re-design featuring a rosette extension (a), a newly designed anchoring device closed (b) and open (c)

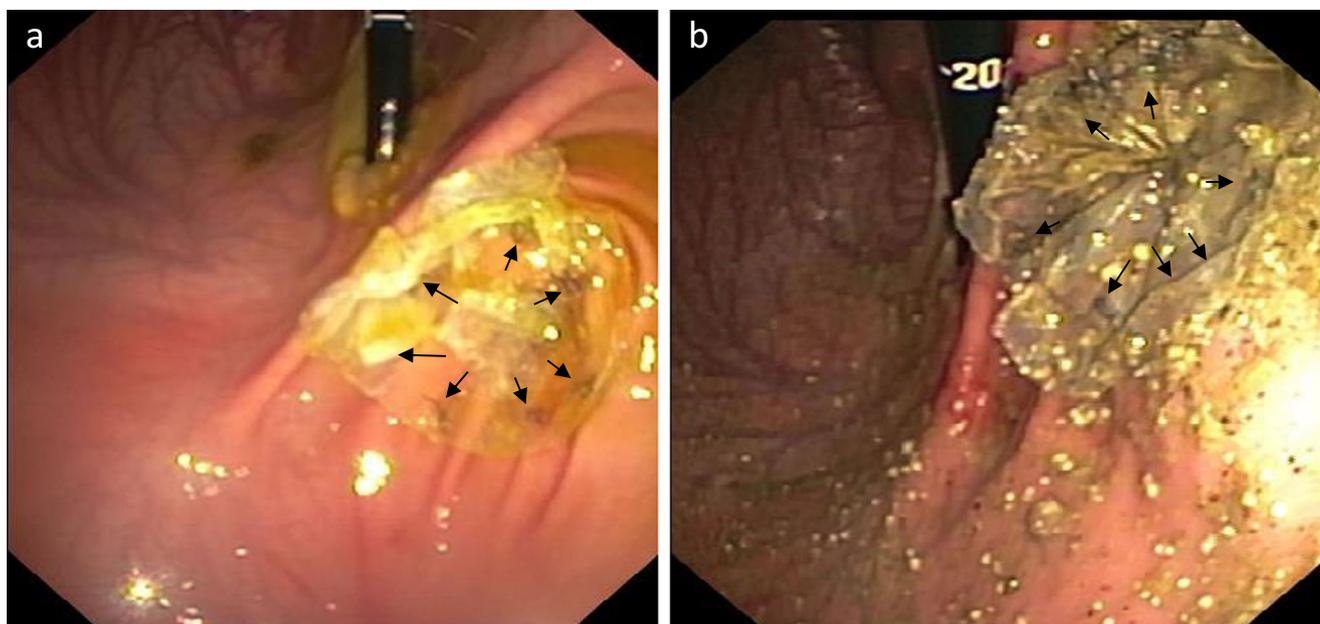


abscesses [3]. In a RCT, Koehestanie et al. report higher adverse effects in 79.3% of patients in the DJBL group compared to the control group 59%. Their effects were mainly abdominal pain/discomfort, nausea and hypoglycaemic events, with more serious being melaena, vomiting and oesophageal tear [4].

Liver abscess is the most serious complication and was reported in several recent studies [11, 12]. High rate (3.5%) of liver abscesses was also a reason for the suspension of a

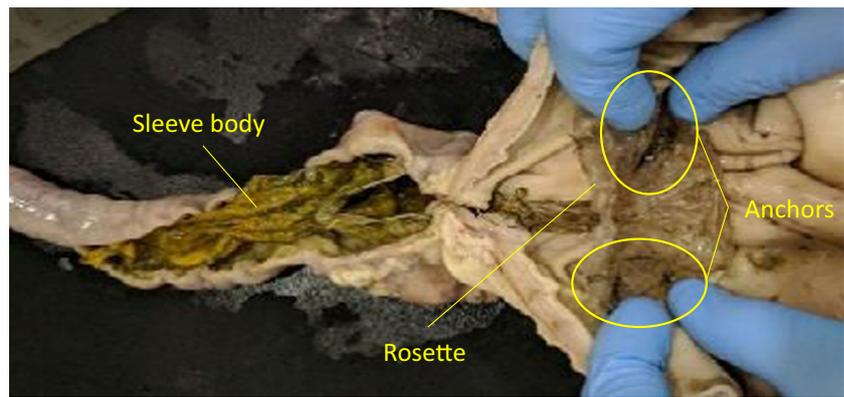
recent multicentre, double-blinded RCT investigating the efficacy and safety of EndoBarrier™ [13]. In our personal series of 100 implants of the device, there have been incidents of ‘haematemesis melaena’ migration and one liver abscess, which was thought to be related to the device.

There has been thought that the causative process for these complications may be the DJBL device anchoring system. The 10 sharp barbs on the circular fixator system could be impinging into the duodenal mucosa causing repetitive trauma



**Fig. 2** Duodeno-jejunal bypass re-designed liner fixed onto the pylorus at the start of the trial (a) and 1 month post-implantation (b). Black arrows indicate placement of anchors

**Fig. 3** Device in-situ post-mortem



during the passage of food and the peristaltic movement of the bowel. Knowing that vascular drainage of this area goes into the portal system, it was therefore postulated that the current anchoring system may serve as a conduit of bacteria into the liver causing liver abscesses. The instability of the fixation system may also be a contributing factor to the migration of the device and the cause of gastrointestinal bleeding.

In this preliminary animal study, we tested a newly developed anchoring system for DJBL, with the latter also modified to suit the new fixation method.

## Materials and Methods

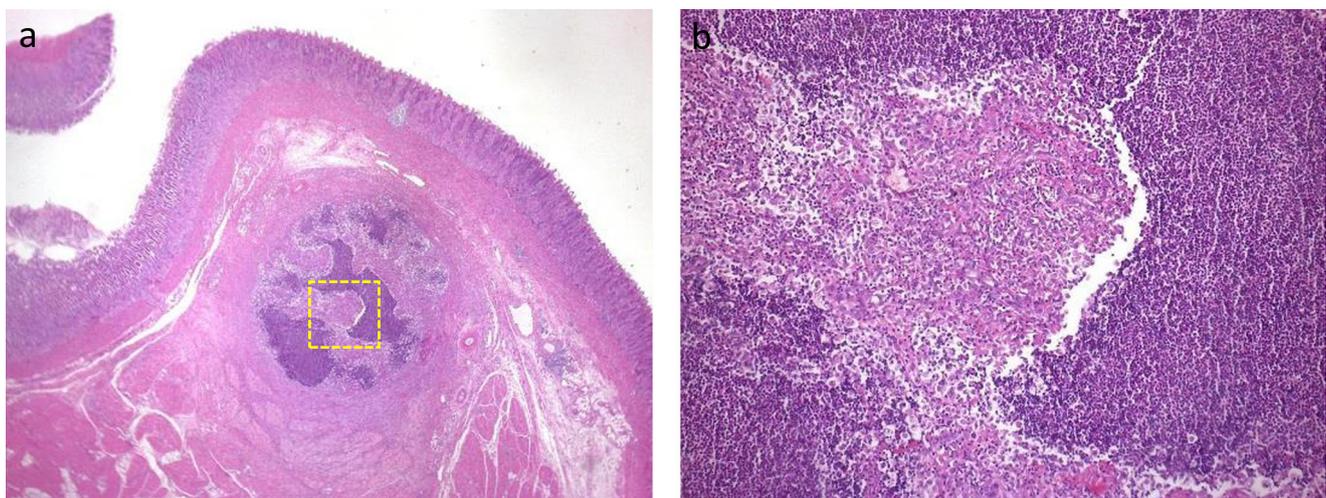
A newly designed DJBL, fitted with a circular expanded anchor (with no barbs) together with a conical shaped polymer rosette extension (Fig. 1a). A novel anchoring device was developed to provide stronger fixation of the liner by attachment to the pyloric antrum rather than the proximal duodenum used in the previous device. (Fig. 1b). The strength of fixation was first investigated during prior bench trials.

During bench trials, the new anchoring mechanism was shown to withstand significant multi-directional pulling forces, exceeding those expected post-implantation in vivo, giving us the confidence to proceed with animal trials.

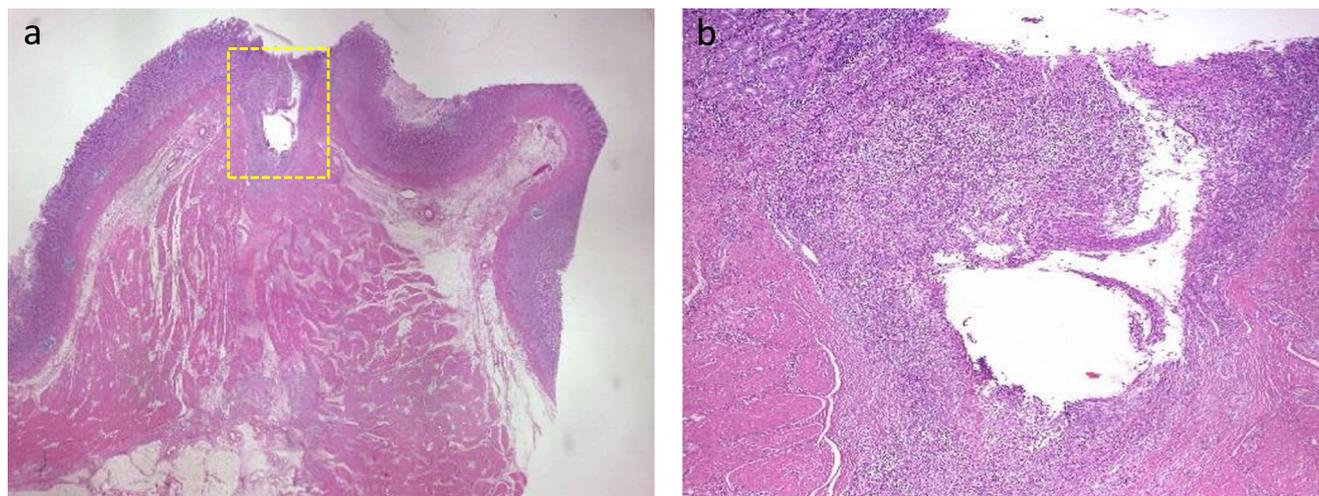
The modified DJBL sleeve and its fixation method were trialled in vivo using two adult pigs. Both pigs were maintained together with the same diet over the 2-month period. All applicable or national guidelines for the care and use of animals were followed, and Ethics Committee approval was obtained. The aims were to investigate the feasibility of implantation of the modified liner using the novel anchoring system and the ability of the liner to stay fixed over a period. We screened for possible complications such as bleeding or inflammation. The weight gain of the pigs was also monitored.

## Implantation Procedure

The new device was endoscopically placed with the anchor in the proximal duodenum, and the attachment pulled through the pylorus. The rosette was fixed to the pyloric antrum proximally with 12 newly designed anchors positioned around the



**Fig. 4** Post-mortem histological assessment. Submucosal inflammatory focus under normal (a) and high-powered magnification (b)



**Fig. 5** Post-mortem histological assessment showing fissures and acute/chronic inflammatory cells under normal (a) and high-powered magnification (b)

rosette (Fig. 2a). At first, a single anchor was fixed to hold the device from migrating, then followed by placement of other anchors around the rosette edges. One pig was rescoped 1 month post-implantation to observe the device.

### Post-Mortem Assessment

The pigs were sacrificed at 2 months, and stomachs with the device in place were subject to histological examination.

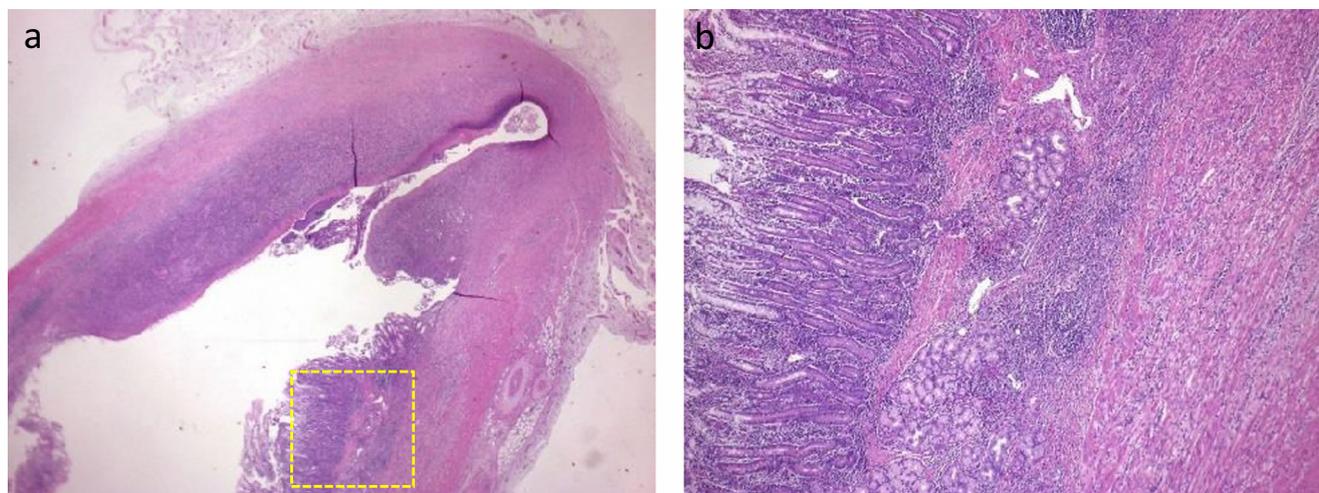
### Results

**Pig ①:** Initially, some technical problems occurred with the delivery system. Subsequently, the device was installed with the rosette anchored to the pylorus (Fig. 3). One month later, the pig was rescoped and the device was found to be intact with no displacement (Fig. 4).

**Pig ②:** There were some technical problems in delivery initially, and the rosette was anchored eccentrically, with anchors distributed non-uniformly. The device was subsequently passed PR after 3 days.

Both pigs had an initial weight of 35 kg. At 2 months, pig ① reached 48.5 kg and pig ② reached 56.5 kg. Pig ① had the new device staying intact post-implantation and also showed less weight gain over 1 month.

At 1 month, pig ① was sacrificed and its stomach dissected. The device held firmly in place by the anchors with a visible lumen of the sleeve containing food particles, indicative of the device functioning in a non-obstructive manner. Both pigs had normal gastrointestinal passages. There were no observed untoward effects on either of the pigs including signs of tissue damage or bleeding. Histological assessment of pig ① showed minor inflammation around the site of the fixation with anchoring devices (Figs. 4 and 5) and some pressure effects of the circular anchor without barbs in the duodenum (Fig. 6).



**Fig. 6** Pressure effect of the anchor without barbs in the duodenum shown under normal (a) and high-powered magnification (b)

## Discussion

Currently, the prolonged use of current DJBL devices as a treatment strategy is hindered. Though yet unsubstantiated by research, it is believed that the anchoring system has a significant effect on the development of complications and device migration, thus limiting the use of this promising technology. In this study, we examined the feasibility of the new anchoring system being used as an alternative fixation method and showed that in animals the device can hold a modified liner in place for 1 month whilst preserving its function. We did not observe serious side effects with seemingly acceptable levels of resulting inflammation.

## In Conclusion

This is a report of the initial trial in a pig model of a newly designed DJB liner with an innovative fixation system. It is possible that the improved design and fixation technique may reduce or prevent some of the complications that have been reported with the EndoBarrier™ DJBL device, but may retain the benefits of the device as has been shown in numerous studies. More detailed animal studies are therefore strongly warranted in the future.

## Compliance with Ethical Standards

**Conflict of Interest** The corresponding author, Harry Frydenberg, has funded the research.

Victor Sutorin, Hien Truong, Andrew Ryan and Mikhail Soutorine declare that they have no conflict of interest.

**Ethical Approval Statement** All applicable institutional and/or national guidelines for the care and use of animals were followed.

**Informed Consent Statement** Does not apply.

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