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Band slippage and erosion after laparoscopic gastric banding: a meta-analysis

Rishi Singhal · Catherine Bryant · Mark Kitchen · Khalid S. Khan · Jon Deeks · Boliang Guo · Paul Super

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Abstract *Background* Laparoscopic adjustable gastric banding has the lowest morbidity and mortality rates among the common bariatric procedures. Troublesome complications associated with this procedure include band slippage and erosion, often requiring revisionary surgery. Rates of slippage have decreased, and this appears to be due to changes in surgical technique. In the authors' experience, units with a low slippage rate also have a low erosion rate and vice versa. Thus a systematic review was undertaken to investigate this relationship. *Methods* Electronic databases were searched up to 31 December 2008. Publications focusing solely on laparoscopic adjustable gastric banding with at least 500 patients and a minimum follow-up period of 2 years were included in the study. Publications in languages other than English and those that failed to mention erosion and slippage rates were excluded. Multivariate meta-analyses were conducted separately for the pars flaccida group, the perigastric group, and the combined overall group to pool the average rates of both erosion and slippage for each paper included. The correlation between the occurrence rates for both erosion and slippage then was examined. *Results* The inclusion criteria were met by 19 studies. The mean rates of erosion and slippage were 1.03 and 4.93, respectively. The results demonstrated a statistically significant overall correlation between erosion and slippage rates ($r = 0.48$, $p = 0.032$). A very strong correlation between erosion and slippage was found if the perigastric technique of insertion was used ($r = 0.99$, $p < 0.001$). However, this correlation was not statistically significant where the pars flaccida technique of insertion was used ($r = 0.34$, $p = 0.38$). *Conclusions* The high correlation rate between erosion and slippage for the perigastric group strongly suggests that these complications share a common pathophysiology. This correlation is reduced with the pars flaccida technique, suggesting that perhaps a different etiology is associated with erosion in these studies. Surgical techniques that help to eliminate lap band slippage should also reduce rates of erosion.

Keywords Adjustable gastric banding · Complications · Erosion · Laparoscopic · Obesity · Metaanalysis · Slippage

R. Singhal (✉) · M. Kitchen · P. Super
Upper GI and Minimally Invasive Unit, Heart of England NHS Foundation Trust, Birmingham, UK
e-mail: singhal_rishi@rediffmail.com

C. Bryant
General Surgery, Royal London Hospital, London, UK

K. S. Khan
Department of Obstetrics-Gynaecology & Clinical Epidemiology, University of Birmingham, Birmingham, UK

J. Deeks · B. Guo
Department of Public Health and Epidemiology, University of Birmingham, Birmingham, UK

Gastric banding was described 15 years after the original description of gastric bypass by Mason. Since then, it has grown rapidly in popularity as a bariatric intervention. Laparoscopic adjustable gastric banding (LGB) is the second most commonly performed bariatric procedure worldwide. It is estimated that slightly more than 140,000 LGB procedures were performed worldwide in 2008. In the United States, LGB represents the highest share of all bariatric procedures performed, and in Europe, despite a decline in rates of band insertion over the past 5 years, gastric banding still remains the most popular weight loss surgical procedure [1].

The main advantages of this procedure are its relative simplicity, both conceptually and surgically, and its low rates for postoperative morbidity and mortality. Despite this, uptake levels remain less than 50% [1], probably due to a previously high reported rate of postoperative complications in some units [2]. The most serious of these complications are band slippage and erosion.

Slippage rates have fallen dramatically over the past few years following a change from the perigastric to the pars flaccida method of band insertion. Rates of slippage can be lowered further by the use of gastric fixation sutures provided the band is not fixed too low on the gastric wall [3]. The existing literature gives a general impression of a relationship between declining slippage and erosion rates and perhaps also improved operative techniques. However, this relationship has not been formally quantified.

The pathophysiology of erosion is poorly understood. Possible mechanisms include infection of the band from visceral damage during insertion, inflammatory reaction between the implant and the gastric wall dependant on synthetic material [4], and possible direct action of ulcerogenic drugs on the mucosal surface of the gastric pouch above the band.

In our experience, slippage has been linked directly to erosion because when slippage occurred, a lack of prompt treatment or revision led to erosion in some cases. Furthermore, we also believe that appropriate surgical dissection and fixation techniques help to reduce slippage rates and thereby may also reduce erosion rates. To clarify this, we conducted a meta-analysis to examine the relationship between band erosion and slippage rates.

Methods

Identification of studies

We conducted a comprehensive review of all studies published in the English literature containing data on slippage and erosion rates. We performed an electronic search in MEDLINE, Current Contents, and the Cochrane Library for interventional or observational studies published from 1 January 1990 to 31 December 2008, including electronic publications within this period. The search terms used were "obesity/surgery (MeSH) OR gastric banding AND erosion AND slippage AND complications."

The studies identified were selected for further review, and data extraction was based on protocol-defined criteria. Only English language studies with at least 500 patients and 2 years of follow-up assessment were included in the study. Multiple publications of the same or overlapping series of patients were identified, and only the latest publication from each unit was included. Substudies not representative of the obese population (e.g., those investigating only superobese patients or only the extremes

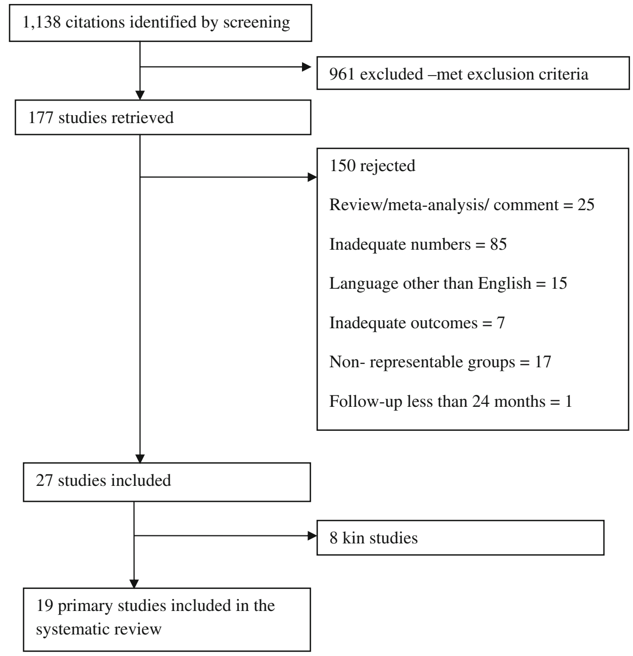


Fig. 1 Study attrition diagram

of age) were not included. Studies with incomplete data regarding overall erosion and slippage rates were not included (Fig. 1).

Data extraction

Two investigators (C.B., M.K.) extracted the data using a standard form. The minimum data set for each study included study size, technique of band insertion (pars flaccida vs perigastric method), overall follow-up evaluation, and the overall erosion and slippage rates. The rates of erosion and slippage were further broken down according to the technique of band insertion if applicable. In case of incomplete technique-specific data, the individual authors were contacted to provide such data (i.e., erosion and slippage rates).

Data analysis

The erosion and slippage proportion of each study was calculated and transferred to the logit scale. The variance of each logit proportion also was calculated. The logit proportion and its variance were used for multivariate meta-analysis [5, 6]. The pooled logit finally was transferred back to proportion and reported. The association between erosion and slippage was reflected by the correlation of logit erosion and logit slippage proportion. This correlation was derived from the covariance estimates of logit slippage and logit erosion proportion at the study level.

The confidence interval of correlation was calculated based on the logit erosion and logit slippage variance and covariance estimates using the delta method. The multivariate metaanalysis model run by STATA 11.0 (Stata Corporation, College Station, Texas, USA) Mvmeta1 command was used to pool the proportion of erosion and slippage across the studies and to explore the association between erosion and slippage [6]. Patient-per-year and study time scale effects on the association estimates were explored by the multivariate meta-regression model [6]. All these analyses were performed for the overall data and the technique-specific data (i.e., pars flaccida vs perigastric method).

Results

Search yields

Initially, a total of 1,138 citations were screened, with 961 studies rejected because they did not satisfy the inclusion criteria. Thus, 177 full-text publications eventually were retrieved, 150 of which were subsequently rejected. Of the remaining 27 studies, 8 were excluded because they were identified to be kin studies. Thus, our final data set consisted of 19 primary studies that met the criteria for inclusion in the extractable and analyzable data set [3, 7–24] (Fig. 1).

Study characteristics

All 19 studies in the data set had a minimum of 500 patients, a 2-year follow-up period, and a report of their overall erosion and slippage rates. Table 1 presents the study characteristics.

Outcomes were examined for a total of 19,657 patients in this study, with a mean of 1,035 patients (range, 500–2,411 patients) per study. The mean follow-up period was 6.2 years (range, 3–12 years), and the total follow-up period was 118 years. The study follow-up period was used to evaluate time scale effects in the model (i.e., to evaluate the effect of the length of the study on the results). A new measure of patients per year was derived by dividing the total patients in the study by the time scale. This measure was used to evaluate the effect of the number of operations performed yearly in the model.

The mean rates for erosion and slippage were respectively 1.03 (range, 0–3.7) and 4.93 (range, 0.3–12.5). Three studies used the perigastric technique of insertion only, whereas seven studies used the pars flaccida technique, and

Table 1 Attributes of publications included in the metaanalysis

Author	Year published	Total no. of patients	Timescale	No. of patients (PG)	No. of patients (PF)	Erosion (overall)	Slippage (overall)	Erosion (PG)	Slippage (PG)	Erosion (PF)	Slippage (PF)
O'Brien et al. [15]	2002	709	6	709	0	2.80	12.50	2.80	12.50		
Belachew et al. [8]	2002	763	4	763	0	0.90	8.00	0.90	8.00		
Vertruyen [22]	2002	543	7	543	0	1.00	4.60	1.00	4.60		
Ceelen et al. [10]	2003	625	4	0	625	0.00	5.60			0.00	5.60
Weiner et al. [24]	2003	984	8	577	407	0.30	4.47	0.35	7.45	0.25	0.25
Angrisani et al. [7]	2003	1863	6	NA	NA	1.10	4.80				
Steffen et al. [19]	2003	824	5	0	824	1.60	2.70			1.60	2.70
Chevallier et al. [11]	2004	1,000	7	378	622	0.30	10.40		24.00		2.00
Dargent [12]	2004	1180	8	511	669	1.86	8.89	2.93	12.10	1.05	6.42
Parikh et al. [16]	2004	749	3	0	749	0.10	2.90			0.10	2.90
Holloway et al. [14]	2004	504	3	0	504	1.00	5.00			1.00	5.00
Ponce et al. [17]	2005	1014	4	44	970	0.20	2.30	0.00	20.50	0.21	1.40
Spivak et al. [18]	2005	500	3	0	500	0.20	2.80			0.20	2.80
Favretti et al. [13]	2007	1791	12	1393	384	0.90	3.90	1.00	4.95	0.52	0.26
Toouli et al. [21]	2008	1000	11	42	958	3.10	3.00		66.60		0.21
Biagini & Karam [9]	2008	591	10	106	485	3.72	5.30	14.15	18.86	1.44	2.06
Singhal et al. [3]	2008	1140	4	0	1140	0.08	0.26			0.08	0.26
Watkins et al. [23]	2008	2411	5	0	2411	0.12	5.10			0.12	5.10
Thornton et al. [20]	2008	1466	8	87	1359	0.35	1.23	1.15	9.19	0.29	0.74

NA not available

Table 2 Pooled erosion and slippage proportion and correlation

Data	Pooled erosion proportion (95% CI)	Pooled slippage proportion (95% CI)	Correlation (95% CI)
Overall data	0.70 (0.41–1.22), $p = 0.000$	4.13 (2.97–5.72), $p = 0.000$	0.48 (0.04–0.92), $p = 0.032$
PG data	3.84 (1.35–10.44), $p = 0.000$	13.32 (7.68–22.12), $p = 0.000$	0.99 (0.95–1.04), $p = 0.000$
PF data	0.41 (0.22–0.76), $p = 0.000$	1.81 (1.02–3.22), $p = 0.000$	0.34 (–0.41–1.09), $p = 0.377$

CI confidence interval, *PG* perigastric, *PF* pars flaccida

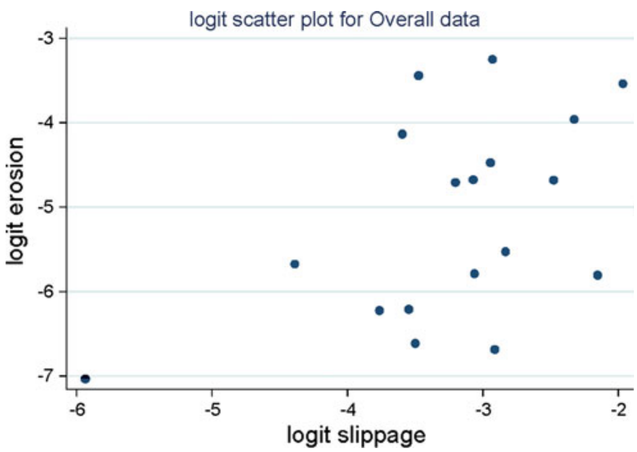


Fig. 2 Scatter plot of logit erosion versus logit slippage for overall data

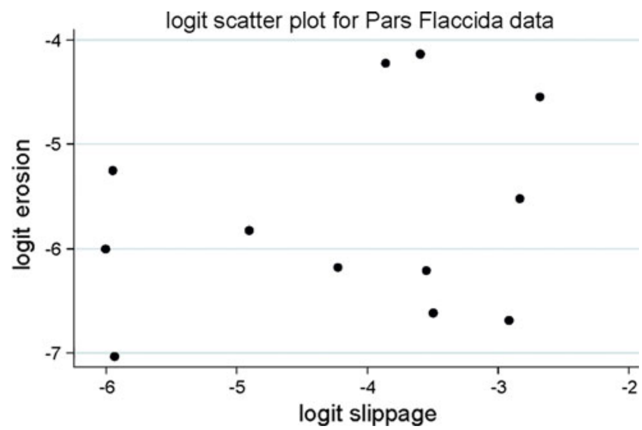


Fig. 3 Scatter plot of logit erosion versus logit slippage for pars flaccida data

the remaining nine studies used a combination of these techniques. In the study by Angrisani et al. [7], data comparing the perigastric and pars flaccida techniques individually were not extractable. Hence, data were analyzed from 9 studies for the perigastric technique [8, 9, 12, 13, 15, 17, 20, 22, 24] and 13 studies for the pars flaccida technique [3, 9, 10, 12–14, 16–20, 23, 24], whereas all 19 studies were included to calculate overall correlation.

Results of meta-analyses

The correlation between erosion and slippage was positive and statistically significant ($r = 0.48$, $p = 0.032$) when the overall data were analyzed (Table 2; Fig. 2). No statistically significant correlation between erosion and slippage was found when the data were analyzed for studies that used the pars flaccida technique (Table 2; Fig. 3). However, the correlation from studies using the perigastric technique was positive and highly significant ($r = 0.99$, $p = 0.000$) (Table 2; Fig. 4). There was significant heterogeneity among studies for overall erosion ($I^2 = 86.8\%$) and slippage ($I^2 = 93.5\%$) (Figs. 5 and 6).

Patient per year and time scale had no significant effect on the correlation estimates from overall data and perigastric data. For the pars flaccida data, after adjustment for patient-per-year effects, the correlation between erosion and slippage became positive and statistically significant ($r = 0.77$, $p = 0.004$). Time scale had only marginal effects on the correlation between erosion and slippage. The correlation with time scale effects adjusted was 0.56 ($p = 0.051$).

Discussion

Slippage is defined as prolapse of the gastric wall proximally through the band. Slippage rates have fallen dramatically over the past few years following a change from the perigastric to the pars flaccida method of dissection. Ponce et al. [17] reported a slippage rate reduction from 20.5% to 1.4% when the technique was changed from perigastric to pars flaccida. The rates of slippage can be lowered further using gastropexy and gastro-gastro sutures to fix the band, reducing the prolapse of the gastric wall through the band [3].

Erosion is defined as the process of intragastric band migration, which causes the fabric of the band to erode through the layers of the gastric wall to appear visible in the lumen of the stomach. For some time, erosion of the band has been an accepted yet poorly understood complication of LGB. Meir and Van Baden [4] suggested four different etiologic hypotheses for erosion of the band: (1) abnormal reaction of the periprosthesic tissue in response to the presence of the band, (2) infection of the band site,

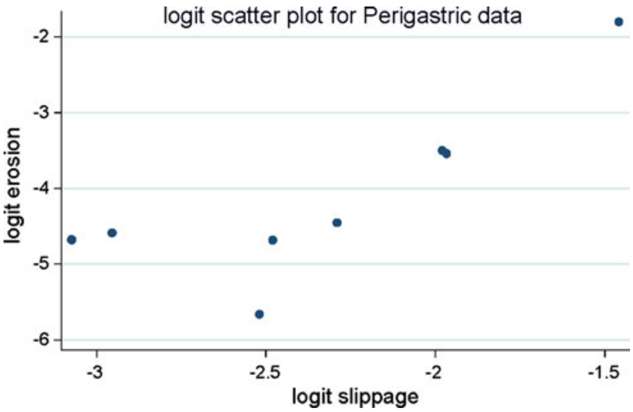


Fig. 4 Scatter plot of logit erosion versus logit slippage for perigastric data

(3) excessive inflation of the band and consequent ischemia of the gastric wall, and (4) damage of the gastric wall during band implantation (due to direct mechanical injury or a diathermy injury from electrocautery). They also suggested that patients with gastric ulcers and those taking aspirin or nonsteroida1 antiinflammatory drugs can be subject to a greater risk of band erosion.

In 2003, Bozbora et al. [25] published an animal model study that evaluated the effect of different synthetic materials used for gastric banding. They found significant differences between the polypropylene and silicone materials in terms of foreign body reaction, lymphocytic infiltration, and invasion of stomach wall ($p < 0.001$), and all reactions were more severe with the polypropylene band. They concluded that silicone was the ideal material for band manufacture because it had good tissue adaptation and caused no inflammatory response.

Because most of the bands currently are made of silicone, the effect of the prosthetic material in the etiology of band erosion is minimal. This was confirmed by Lattuada et al. [26], who in their study analyzed fragments of fibroadipose tissue in close contact with the band that were obtained at the time of band removal. They suggested that band erosion could have a closer correlation with other causes such as infection of the band or intraoperative surgical damage rather than the material of the band.

Infections of the band probably play a role in the etiology of band erosion, particularly early band erosion. Damage to the gastric wall during band implantation could result in microperforations where the mucosa is breached. Tiny areas of contamination and sepsis, made worse by the presence of a foreign body (implant), would then lead to progressive band infection and erosion.

Another possible cause of band erosion, stressed by many authors, is band overfilling [27, 28]. The tighter the band, the greater the force exerted on the gastric wall in direct contact with the band, thus causing excessive gastric wall pressure leading to tissue ischemia and eventual erosion. However this complication would take several days to develop and prior to the development of gastric wall

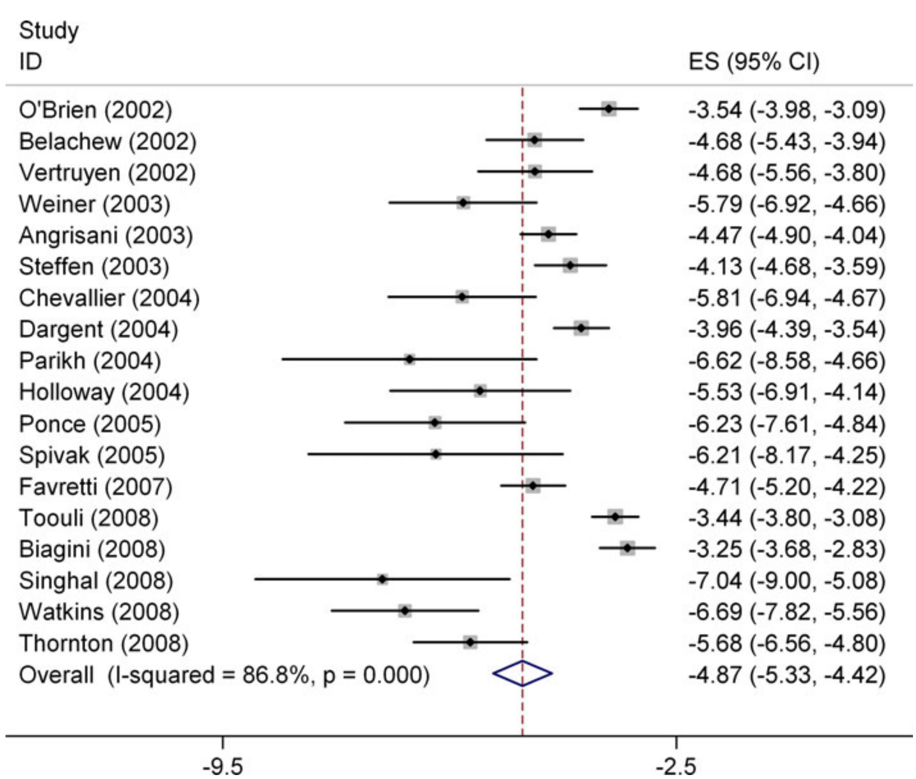
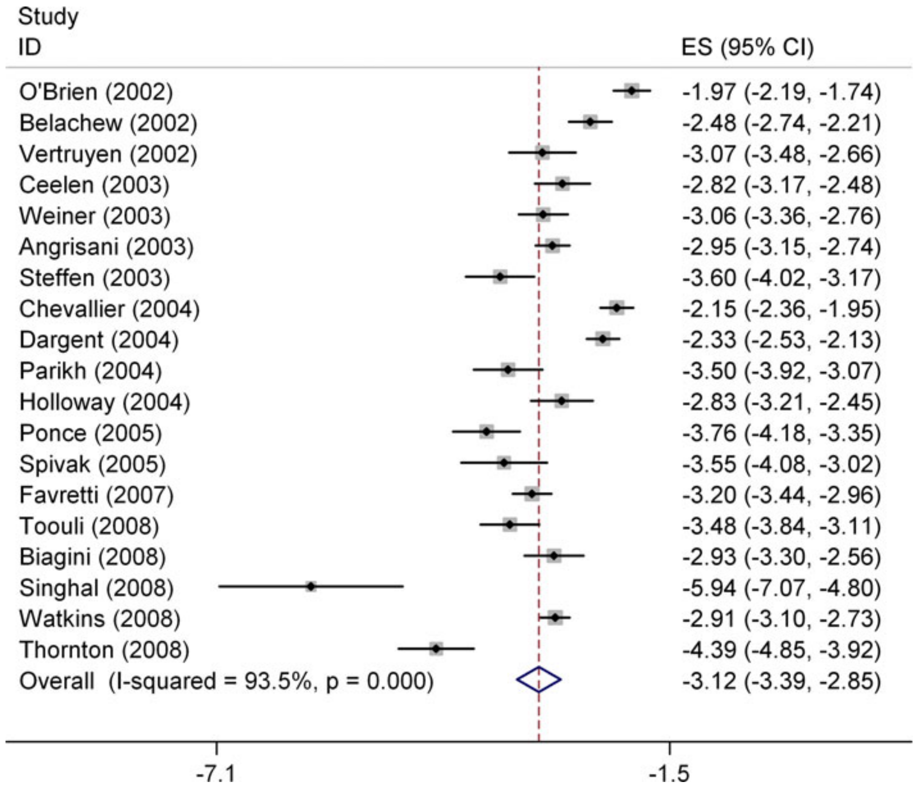


Fig. 5 Forest plot of overall erosion

Fig. 6 Forest plot of overall slippage



necrosis one might expect an urgent patient presentation, with symptoms of overrestriction and intolerance of oral liquids. In this scenario, gastric necrosis cannot be postulated from this event unless there was in addition a failure to treat this emergency presentation by urgent band deflation.

Linked to this, however, and generally acknowledged by many authors is the idea that high pouch pressures can promote pouch dilation and slippage. During this process, the gastric bands usually exert higher than normal pressures on the prolapsed stomach wall due to increased tissue mass in the fixed cross-sectional lumen within the band. Patients in this situation frequently report symptoms of the band being too tight. Thus, in this situation, slippage results in symptoms of overrestriction, which can commonly be intermittent and chronic in nature.

Evidence that slippage and erosion might share another common predisposing factor was suggested by Niville et al. [29] in their series. Two of their five patients who experienced erosion had previously undergone laparoscopic repositioning of the gastric band for pathologic late pouch dilation. The significance of this observation may merely be that redo surgery carries a higher risk of tissue trauma and early infection from microperforation.

To date, in our unit, we have performed 2,421 gastric band insertions over the past 7 years, and in our series, we have had four patients with band erosion. Two of these patients had evidence of a large pouch dilation at their most recent gastrointestinal (GI) contrast study many months before the development of band erosion. The third patient was taking oral methotrexate in tablet form (associated with gastric ulcers), which supports the idea that ulcerogenic drugs could be responsible for some erosions. The fourth patient had an early postoperative erosion at 4 months, almost certainly related to gastric trauma at the time of insertion.

In the current meta-analysis, we noticed a significant correlation between erosion and slippage rates, with studies that had high slippage rates tending to have high erosion rates and vice versa. The correlation between erosion and slippage was highly significant when the perigastric technique of band insertion was used. This correlation provides good evidence for the presence of a common predisposing factor in the etiology of band erosion and slippage. With changes in surgical technique (and perhaps also with improvements in band design over time), this relationship has weakened.

A scenario to support this link between slippage and erosion would be to imagine a GI study showing a distended contrast-filled gastric pouch overhanging the superolateral border of the gastric band (this being radiographic evidence of band slippage in a fasted patient). It could be assumed that if this is not treated, a much larger pouch dilation will occur during normal eating and drinking, with stretching of the pouch over the edge of the band. The portion of the gastric pouch in direct contact with the edge of the band would be subject to high tissue stress and direct pressure. We postulate that this would lead to pressure necrosis if untreated due to repeated episodes of severe tissue pressure on the same portion of gastric wall, which would occur intermittently with each meal. Eventually, there would be breakdown of the gastric wall in direct contract with the superolateral edge of the band, with microperforation and infection. Thereafter, progressive erosion of the band would be inevitable.

It is our belief that improvements in surgical techniques have resulted in a decrease in gastric band slippage and that this may be why we are observing reduced rates of erosion. Complications related to gastric band insertion will never be fully eliminated, but perhaps the most serious—gastric band erosion (or migration)—can be reduced to a minimum by careful attention to surgical technique.

Disclosures Rishi Singhal, Catherine Bryant, Mark Kitchen, Khalid S. Khan, Jon Deeks, Boliang Guo, and Paul Super have no conflicts of interest or financial ties to disclose.

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