

LINX for GERD: Cruroplasty, Proper Sizing, and Outcomes in Special Populations

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ABSTRACT

Magnetic sphincter augmentation (LINX) is a physiology-preserving treatment for gastroesophageal reflux disease that augments lower esophageal sphincter tone while maintaining the ability to belch and vomit. This review synthesizes current evidence on patient selection, operative technique, postoperative care, outcomes, and revision strategies. We outline a practical pathway that starts with objective reflux testing and high-resolution manometry, pairs implantation with durable posterior cruroplasty and correct sizing, and uses a structured early “device cycling” diet to reduce dysphagia. Longitudinal cohorts show sustained symptom relief, reduced proton pump inhibitor use, and favorable quality of life. Early dysphagia is common but typically improves with coaching and hydration, and most persistent cases respond to one or two graded dilations. When removal is necessary, conversion to fundoplication is usually feasible with good results.

Comparative studies position LINX alongside fundoplication, with a trade-off between strict acid normalization and preservation of physiologic venting that supports shared decision-making. The 2024 expansion of the United States label to include symptomatic Barrett’s esophagus broadens candidacy and underscores the need for coordinated endoscopic surveillance. Growing experience in post-bariatric patients suggests a role for LINX when a durable cruroplasty is feasible and a severe motility disorder is absent. A characteristic late failure pattern involves recurrent hiatal hernia with ring slippage or migration, which highlights the value of meticulous hiatal repair and a low threshold for anatomic evaluation during follow-up. Future priorities include phenotype-stratified comparative studies, Barrett’s and post-bariatric registries, and engineering responses that reduce hernia-linked failure while preserving the physiologic benefits that distinguish LINX.

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Background

Gastroesophageal reflux disease (GERD) is common, and a substantial subset of patients live with persistent symptoms or medication intolerance despite optimized proton-pump inhibitor therapy. Magnetic sphincter augmentation (MSA), marketed as the LINX Reflux Management System, was designed to restore lower esophageal sphincter competence

while preserving the ability to belch and vomit. The device consists of interlinked titanium beads with magnetic cores placed laparoscopically around the LES; resting tone resists reflux, and the beads transiently separate during swallowing. Contemporary series and reviews report durable symptom relief, improved GERD-HRQL, and reduced PPI use at mid- to long-term follow-up, while

emphasizing that dysphagia requiring dilation or device removal remains uncommon but real and is influenced by patient selection and hiatal repair technique (Ibrahim et al., 2024; Froiio et al., 2023).

Two recent developments broaden the clinical conversation. First, in August 2024, the U.S. Food and Drug Administration expanded the LINX label to include patients with Barrett's esophagus who have symptomatic GERD, reflecting growing real-world evidence and opening a larger candidate pool (Johnson & Johnson MedTech, 2024). For authors, this invites discussion of endoscopic surveillance and outcomes in BE subsets. Second, head-to-head comparisons continue to refine where MSA sits relative to laparoscopic Nissen fundoplication: a 2024 comparative study reported broadly similar reflux control with functional advantages for MSA in select domains, consistent with prior signals that MSA tends to preserve physiologic venting better even if postoperative dilations or PPI resumption occur in some series (Zhu et al., 2024; Daus et al., 2024).

Attention has also turned to failure modes and revision strategies. A 2025 single-institution case series characterized a consistent pattern of device slippage or migration often accompanied by hiatal hernia recurrence, underscoring the importance of meticulous crural repair and structured follow-up; most patients were successfully managed, including with device explant when indicated (Bloomsburg et al., 2025). These data help sharpen informed consent and quality-assurance benchmarks for MSA programs.

Indications continue to widen in parallel. Mid-term reports suggest MSA can be performed safely in carefully selected post-bariatric patients (e.g., after sleeve gastrectomy or Roux-en-Y) when combined with appropriate hernia repair and multidisciplinary evaluation (Peine et al., 2024; Alkully et al., 2025; Cammarata et al., 2024). These cohorts remain smaller than the primary GERD series, but they provide practical selection cues for surgeons treating complex reflux after weight-loss procedures.

Finally, patients often ask what is “newer” than LINX. No next-generation magnetic augmentation system with comparable regulatory status and extended follow-up has emerged as of 2025. However, lower esophageal sphincter electrical stimulation (EndoStim) remains an alternative concept under investigation. Evidence consists of earlier prospective studies and ongoing or recent reviews, suggesting symptomatic and physiologic improvements in selected patients but with a less mature evidence base than MSA (Rodríguez et al., 2015; Rosen et al., 2025). If mentioned, it is best framed as an emerging option whose role relative to MSA and fundoplication will depend on forthcoming trials.

Device Design, Operative Technique, And Perioperative Management

The LINX magnetic sphincter augmentation system is a ring of interlinked titanium beads with magnetic cores connected by flexible titanium wires. At rest, magnetic attraction augments lower esophageal sphincter (LES) tone to resist reflux. During swallowing or belching, the beads separate along the links so the junction opens briefly and physiologic venting is preserved (DeMarchi et al., 2021; Botteri et al., 2021). Implant size corresponds to bead count and is chosen with a calibrated sizing tool around a decompressed esophagus to match LES circumference (Ethicon, 2016).

Operative success relies on disciplined foregut work. After adequate mediastinal mobilization, close the hiatus posteriorly with a durable cruroplasty and completely reduce the hernia sac. Proper sizing and placement around a relaxed esophagus help avoid excessive constriction and lower the risk of postoperative dysphagia. Avoid trapping scar or fat beneath the device, and confirm that the ring sits freely without undue tension. Programs that standardized mobilization, complete sac reduction, crural repair, and careful sizing reported fewer early dilations and better symptom resolution (Froiio et al., 2023; Sarici et al., 2024).

The postoperative plan aims to keep the device moving while the fibrous capsule forms and to identify treatable dysphagia early. Many centers start a “device cycling” diet the day after surgery that uses small, frequent bites of regular food with thorough chewing and sips of liquid between bites rather than a prolonged soft diet. Persistent dysphagia after the early healing window is usually manageable with graded endoscopic dilation, especially when preoperative motility is acceptable (Sarici et al., 2024). Patients should leave the hospital with clear written instructions and a simple escalation plan if they cannot advance their diet as expected.

Imaging safety requires explicit documentation. LINX implants are MR Conditional with model-specific limits. Early devices were limited to 0.7 T, and newer models are typically cleared up to 1.5 T. Record the exact model and MRI conditions in the operative note and discharge paperwork, and ensure the patient carries the device card so future imaging teams can verify conditions (Ethicon, 2024; MRIsafety.com, 2024).

As indications expand to include symptomatic Barrett's esophagus in the United States, technique matters even more. Durable cruroplasty and consistent sizing reduce the odds of late anatomic failure and the characteristic pattern of ring slippage in the setting of recurrent hiatal hernia.

Early experience also supports carefully selected post-bariatric patients when a solid crural repair is feasible, provided selection and follow-up are disciplined (Johnson & Johnson MedTech, 2024; Cammarata et al., 2024).

Patient Selection and Preoperative Evaluation

Good outcomes with magnetic sphincter augmentation begin with disciplined selection and physiologic confirmation of reflux. Start by clarifying the GERD phenotype and documenting objective reflux. In patients with unproven GERD, perform ambulatory reflux monitoring off acid suppression. pH-impedance testing helps capture acid and weakly acidic events and allows symptom association analysis. In patients with proven GERD who have persistent symptoms on therapy, testing on medication can clarify the failure mechanism and guide the plan (Gyawali et al., 2023; Roman, 2022). High-resolution manometry is required to exclude achalasia and to characterize esophageal body contractility and esophagogastric junction outflow before implantation. These data identify who benefits from mechanical augmentation and who needs an alternative approach (Yodice et al., 2021).

Motility influences risk but is not an absolute barrier. Patients with normal motility have the most reliable pH normalization and symptom relief. Several series associate ineffective esophageal motility with a higher chance of persistent dysphagia or need for dilation after implantation. Selection should weigh baseline swallow vigor, symptom profile, and patient priorities. Provide clear counseling about the possibility of early dysphagia and a low threshold for protocolized dilations if needed. Many centers report that a structured postoperative diet and timely dilation resolve most issues (Froio et al., 2023; Ruiz-Cota et al., 2025).

Hiatal anatomy deserves attention before the operating room. Outcomes depend on the hernia repair as much as on the device. While early use favored small hernias, contemporary practice supports magnetic sphincter augmentation with formal posterior cruroplasty even for larger defects when the repair is durable. Recurrent hernia is a common substrate for late symptom return and device slippage or migration. Preoperative planning should include a careful sizing strategy, complete mediastinal mobilization, and sac reduction. Postoperative follow-up should be structured to detect early anatomic failure (Buckley et al., 2018; Bloomsburg et al., 2025).

Special populations require tailored planning. In August 2024, the United States label was expanded to include patients with Barrett's esophagus who have symptomatic reflux. Selection should be paired with a clear endoscopic

surveillance plan that aligns with society guidance. In post-bariatric cohorts, growing experience supports magnetic sphincter augmentation in carefully chosen cases when a durable cruroplasty is feasible and severe motility disorder is absent. Selection meetings that include foregut surgery, bariatric surgery, and gastroenterology help set realistic goals and reduce revisions (Johnson & Johnson MedTech, 2024; Cammarata et al., 2024; Ibrahim et al., 2024).

Expectations should be transparent. Comparative studies suggest magnetic sphincter augmentation achieves reflux control similar to laparoscopic Nissen fundoplication in many domains, with better preservation of physiologic venting and less gas-bloat. Some series report a higher likelihood of postoperative dilation or PPI resumption. Discuss these trade-offs in plain language and outline the usual dysphagia timeline, the "device cycling" diet, and the dilation pathway so patients know what to expect and when to call (Ibach et al., 2024; Daus et al., 2024; Froio et al., 2023).

Outcomes, Safety, and Comparative Effectiveness

Magnetic sphincter augmentation provides durable relief for well-selected patients with GERD. Longitudinal cohorts and systematic reviews report sustained improvement in GERD-HRQL, reduction or cessation of proton pump inhibitors, and preservation of belching and vomiting at mid- to long-term follow-up. Programs with 6 to 12 years of surveillance suggest stability of these outcomes as technique and postoperative care have been standardized (Ibrahim et al., 2024; Puri, 2023; Ferrari et al., 2020).

Adverse events are usually manageable. Transient dysphagia is common in the first weeks and often resolves with diet coaching and hydration. Persistent symptoms after the early healing window respond to graded endoscopic dilation in most patients, particularly when preoperative motility is acceptable. Device removal remains uncommon in modern series, and conversion to fundoplication is typically feasible with reasonable symptom control when needed (Froio et al., 2023). A recent failure-pattern report described device slippage or migration frequently accompanying recurrent hiatal hernia, which highlights the value of meticulous crural repair and structured follow-up to identify anatomic failure before symptoms escalate (Bloomsburg et al., 2025).

Comparative studies position magnetic sphincter augmentation alongside laparoscopic Nissen fundoplication rather than as a lesser option. A 2024 head-to-head analysis found broadly similar reflux control, with functional advantages for magnetic augmentation in selected domains, while a 2025 network meta-analysis suggested

fundoplication may produce larger improvements in pH metrics than magnetic augmentation or transoral incisionless fundoplication. These signals support counseling that turns on patient priorities: strict acid normalization for some versus preservation of physiologic venting and lower gas-bloat for others. Database studies also suggest shorter operative time, shorter length of stay, and fewer short-term complications with magnetic augmentation compared with fundoplication, although selection factors should be acknowledged when interpreting these findings (Zhu et al., 2024; Tadé et al., 2025; Wisniowski et al., 2024).

Indications continue to broaden. In August 2024, the United States label was amended to include patients with Barrett's esophagus who have symptomatic reflux, which widens candidacy and calls for coordinated endoscopic surveillance after implantation. Experience is also growing in post-bariatric cohorts when a durable cruroplasty is feasible and motility is acceptable, offering an alternative to immediate revisional bypass in carefully selected patients (Johnson & Johnson MedTech, 2024; Cammarata et al., 2024; Ibrahim et al., 2024; Peine et al., 2024).

Postoperative Care and Follow-Up

Early care focuses on restoring comfortable swallowing, preventing a restrictive capsule, and spotting anatomic problems before they escalate. Many programs begin a "device cycling" diet the day after surgery. Patients eat small, frequent bites of regular food every two to three hours, chew thoroughly, and sip liquids between bites. The goal is to keep the ring opening and closing as the fibrous sheath matures, which reduces the chance of stiffness and late dysphagia. Written instructions, a short list of easy starter foods, and a direct call line help patients progress with confidence (Ayazi et al., 2019; Sarici et al., 2024).

Dysphagia usually follows a predictable time course. Mild to moderate difficulty swallowing often peaks around weeks three to six. Reassurance, hydration, and diet coaching are first-line. If symptoms persist beyond the early healing window or if weight loss and food avoidance develop, schedule graded endoscopic dilation. Most patients improve after one or two sessions, particularly when preoperative motility was acceptable (Ayazi et al., 2019; Froiio et al., 2023). An upright contrast swallow can clarify whether symptoms reflect edema and capsule formation or an early anatomic issue.

Follow-up visits at two to three weeks and again at six to eight weeks allow the team to reassess swallowing, diet progression, and reflux control. New or recurrent heartburn, chest discomfort, or regurgitation after an initial reasonable period should raise suspicion for a hiatal problem. Recent reports describe a characteristic failure

pattern of device slippage or migration that often occurs with recurrent hiatal hernia. A low threshold for anatomic evaluation and timely repair prevents prolonged symptoms and protects outcomes (Bloomsburg et al., 2025).

Imaging safety deserves explicit documentation. LINX implants are MR Conditional with model-specific limits. Early devices were limited to 0.7 tesla, and newer models are typically cleared up to 1.5 tesla. Record the exact implant model and MRI conditions in the operative note and discharge paperwork, and ensure the patient keeps the device card available for radiology teams (Ethicon, 2024; MRI safety.com, 2024).

Patients with Barrett's esophagus need a surveillance plan that follows society guidance rather than ad hoc schedules. After endoscopic eradication therapy, current U.S. guidelines recommend surveillance at year one and year three after complete eradication of intestinal metaplasia, then a return to standard nondysplastic intervals. For nondysplastic Barrett's managed without eradication, continue risk-stratified surveillance at the usual cadence. Document who will coordinate endoscopy and place reminders in the chart to avoid gaps (AGA Clinical Practice Guideline, 2024).

Complications, Failure Modes, and Revision Strategies

Complications after magnetic sphincter augmentation are usually manageable when teams anticipate them and act early. Dysphagia is the most common issue in the first weeks. It often peaks around weeks three to six as edema settles and the capsular sheath matures. Most patients improve with reassurance, hydration, and a structured "device cycling" diet. Persistent symptoms beyond the early healing window respond to graded endoscopic dilation in the majority of cases, particularly when preoperative motility was acceptable (Ayazi et al., 2019; Froiio et al., 2023).

Erosion and explantation are uncommon in modern series. When removal is required for refractory dysphagia or symptom recurrence, conversion to fundoplication is typically feasible with good outcomes in experienced hands. Counseling patients that device removal remains an option can reduce anxiety if early swallowing symptoms are slow to resolve (Froiio et al., 2023).

A consistent anatomic failure pattern has been described in recent work. Device slippage or migration often occurs together with recurrent hiatal hernia. This link highlights the importance of complete sac reduction, adequate mediastinal mobilization, and durable posterior cruroplasty at the index operation. When late reflux, regurgitation, or chest discomfort returns after an initial reasonable period,

a low threshold for upright contrast swallow or cross-sectional imaging can identify anatomic failure before symptoms escalate. Timely repair, with or without device revision or explant, restores control for most patients (Bloomsburg et al., 2025).

MRI safety remains a preventable pitfall. LINX implants are MR Conditional with model-specific limits. Early devices were limited to 0.7 tesla, and newer models are typically cleared up to 1.5 tesla. Document the exact model and MRI conditions in the operative note and discharge paperwork, and ensure the patient carries the device card so radiology teams can verify conditions before scanning (Ethicon, 2024; MRI-safety.com, 2024).

When revision is needed, a stepwise approach keeps risk low. Confirm reflux physiology and motility, define the anatomy of the hiatus, repair the crura durably, and choose between re-implantation, fundoplication, or medical therapy based on goals and findings. Setting expectations about diet, the usual dysphagia timeline, and the possibility of a single dilation after reintervention helps patients recover with confidence.

Quality of Life, Economics, and Shared Decision-Making

Patient experience often drives the choice between magnetic sphincter augmentation and fundoplication. Across recent series, magnetic augmentation improves GERD-HRQL and reduces proton pump inhibitor use at mid to long term, while most patients retain the ability to belch and vomit. Head-to-head comparisons generally show similar reflux control to laparoscopic Nissen fundoplication, with magnetic augmentation performing better in day-to-day comfort for many patients. A 2025 network meta-analysis suggested fundoplication may achieve larger improvements in pH metrics than magnetic augmentation or transoral incisionless fundoplication, which helps frame an honest discussion about priorities. Patients who value strict acid normalization may prefer fundoplication, whereas those who prioritize physiologic venting and less gas-bloat may favor magnetic augmentation (Zhu et al., 2024; Tadé et al., 2025; Puri, 2023; Ferrari et al., 2020).

Cost and resource use matter to patients and health systems. Extensive database studies suggest magnetic augmentation can shorten operative time and length of stay compared with fundoplication, which may offset device costs in some settings. However, selection effects and institutional learning curves need to be acknowledged when interpreting these data (Wisniowski et al., 2024). Counseling should also cover what happens if recovery is not perfectly smooth. Early dysphagia usually peaks around weeks three to six and improves with diet coaching

and hydration. Most persistent cases respond to one or two graded dilations, and device removal does not preclude successful conversion to fundoplication when indicated (Ayazi et al., 2019; Froio et al., 2023).

Two developments influence shared decisions today. The United States label now includes patients with Barrett's esophagus who have symptomatic reflux, which broadens candidacy and makes coordinated post-implant endoscopic surveillance essential. Growing experience in post-bariatric cohorts shows magnetic augmentation can work in carefully selected patients when a durable cruroplasty is feasible and severe motility disorder is absent. These points belong in the preoperative conversation so patients can weigh symptom goals, lifestyle preferences, surveillance obligations, and the slight possibility of dilation or revision against the benefits of preserved physiologic function and rapid recovery (Johnson & Johnson MedTech, 2024; Cammarata et al., 2024; Ibrahim et al., 2024; Peine et al., 2024).

Alternatives and future directions

Magnetic sphincter augmentation has matured into a durable option for GERD, and recent regulatory changes broaden its reach. In August 2024, the United States Food and Drug Administration expanded the LINX label to include patients with Barrett's esophagus who have symptomatic reflux. This widens candidacy and places more emphasis on coordinated endoscopic surveillance after implantation (Johnson & Johnson MedTech, 2024).

Lower esophageal sphincter electrical stimulation offers a mechanistically distinct alternative that does not compress the junction. Early prospective studies and programmatic reviews report symptom improvement and better acid exposure in selected patients, although the evidence base remains smaller and less mature than for magnetic augmentation. Head-to-head comparisons with fundoplication or LINX are limited, and ongoing trials will determine durability and the right candidates for this approach (Rodríguez et al., 2015; Rosen et al., 2025).

Endoscopic and nonmagnetic surgical options continue to evolve. Transoral incisionless fundoplication provides symptom benefit and PPI reduction in carefully selected phenotypes. Network meta-analysis suggests laparoscopic Nissen fundoplication may more consistently normalize pH metrics than magnetic augmentation or TIF, which helps frame procedure choice around what patients value most, whether strict acid normalization or preservation of physiologic venting and day-to-day comfort (Tadé et al., 2025; Zhu et al., 2024). RefluxStop, a nonmagnetic implant that repositions and stabilizes the gastroesophageal junction rather than compressing the LES, has growing

European experience and cost-effectiveness modeling, with 5-year outcomes reported as part of an FDA submission pathway. These data illustrate a broader trend toward anatomy-preserving implants, although RefluxStop is not interchangeable with magnetic augmentation and United States adoption is still evolving (Targarona et al., 2021; RefluxStop Health Economic Dossier, 2023).

Failure-mode analyses are guiding practical innovation. A 2025 single-institution series described a consistent pattern of ring slippage or migration that often accompanies recurrent hiatal hernia. This map of anatomic failure points to concrete development targets that include improved sizing tools, better intraoperative fixation concepts, and structured surveillance that detects early hernia recurrence before symptomatic failure (Bloomsburg et al., 2025).

Special populations remain a frontier. Systematic reviews and cohort studies suggest magnetic augmentation can be effective after sleeve gastrectomy in carefully selected patients when a durable cruroplasty is feasible and severe motility disorder is absent. Future work should stratify outcomes by anatomy, motility, and body mass index to clarify who benefits most and which revision pathways are preferable when symptoms recur (Cammarata et al., 2024; Peine et al., 2024; Ibrahim et al., 2024).

MRI conditionality has improved across device generations, but remains model-specific. Early implants were limited to 0.7 tesla, and newer models are typically cleared up to 1.5 tesla. Clear documentation of the implant model and MRI limits in the operative note and discharge paperwork reduces avoidable risk and should be standard in every program (Ethicon, 2024; MRIsafety.com, 2024).

Near-term priorities include phenotype-stratified comparative studies that align pH metrics with patient-reported outcomes, Barrett's and post-bariatric registries that track durability and surveillance adherence under the expanded label, engineering responses to hernia-linked failure, and robust trials or registries for electrical stimulation and new implants to define their niche relative to magnetic augmentation and fundoplication. These steps should sharpen selection, reduce revisions, and broaden access to physiology-preserving options.

Conclusion

Magnetic sphincter augmentation is a reliable, physiology-preserving option for carefully selected patients with GERD. Outcomes are strongest when teams confirm reflux physiology, repair the hiatus durably, size the device correctly, and coach an early "device cycling" diet. Most patients achieve durable symptom control with reduced PPI use and preserved belching and vomiting. Early dysphagia is common yet usually improves with coaching and

hydration, and persistent cases often respond to one or two graded dilations. When removal is necessary, conversion to fundoplication is typically feasible with good results.

Late failure most often reflects recurrent hiatal hernia with associated ring slippage or migration. Meticulous mediastinal mobilization, complete sac reduction, and solid posterior cruroplasty reduce this risk, and a low threshold for anatomic evaluation shortens the path to effective revision.

Shared decisions should weigh trade-offs. Fundoplication may yield larger improvements in acid metrics for some patients, while magnetic augmentation often provides similar symptom relief with better day-to-day comfort. The expanded U.S. label covering symptomatic Barrett's esophagus and growing experience in post-bariatric cohorts broaden candidacy, provided surveillance and selection are disciplined. Future work should deliver phenotype-stratified comparisons, targeted registries, and engineering responses to hernia-linked failure.

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