Extensive regeneration of the stomach using bioabsorbable polymer sheets

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Background. *The growing prevalence of endoscopic surgery in recent years has led to the minimization of postoperative scarring. However, this procedure does not allow for the regeneration of the resected digestive tract, which compromises the postoperative maintenance of digestive function. In this preliminary study, we developed an artificial gastric wall (AGW) using bioabsorbable polymer (BAP), and evaluated the ability of this BAP patch to repair and regenerate a widely defective gastric wall in an animal model.*

Methods. *Pigs were laparotomized under general anesthesia. An 8 × 8-cm, round portion of the anterior gastric wall was excised and replaced by an AGW. The AGW was composed of a copolymer comprising 50% lactic acid and 50% caprolactone. The animals were relaparotomized 4, 8, or 12 weeks after implantation, after which they underwent resection of the entire stomach for gross and histologic evaluation of the graft sites.*

Results. *All recipient pigs survived until killing. By 4–8 weeks, the graft site revealed progressively fewer mucosal defect after each day. Moreover, the grafted area was indistinguishable from the native stomach 12 weeks after AGW implantation. The structures of the regenerated mucous membrane and muscle layers were identical to those of the native stomach. Furthermore, proton pumps were found in the regenerated tissue.*

Conclusion. *The BAP sheets helped to restore extensive gastric defects without causing any deformation. The use of BAP sheets may become a new therapeutic method that prevents alterations of gastric volume after extensive gastrectomy for stomach cancer and other diseases. (Surgery 2015;158:1283-90.)*

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Recently, the prevalence of minimally invasive methods in the field of endoscopic and robotic surgeries has been increasing. Although these methods have helped to minimize wound size and postoperative scarring,[1-3] they are not useful in facilitating the regeneration of a resected digestive tract or the preservation of postoperative biological function.[4,5] Recent progress in diagnostic and therapeutic tools for neoplastic lesions in the stomach has made it possible to resect the stomach with minimal invasion under endoscopic guidance.[6,7] Nevertheless, poorly differentiated cancers and submucosal tumors require total excision of gastric wall layers even when the lesions are small.[8] Even a small lesion can result in deformation and constriction after direct suture closure because of the morphologic characteristics of the stomach, and these conditions can lower considerably a patient's postoperative quality of life. Herein, we investigated the possibility of minimizing this deformation and constriction by regenerating and restoring an excised portion of the gastric wall with an implanted artificial prosthesis and the possibility of avoiding excessive gastric resection. We previously reported the successful regeneration of a bile duct and blood vessels using a unique bioabsorbable polymer (BAP).[9-13] An approach to restore a defect area of the stomach after gastric resection by using a substitute material has been tested in experiments by applying bioabsorbable materials, including small intestinal submucosa or nonbioabsorbable materials. In the present study, an artificial gastric wall (AGW) was fashioned from a modified variant of this BAP.

The authors declare no competing financial interests.

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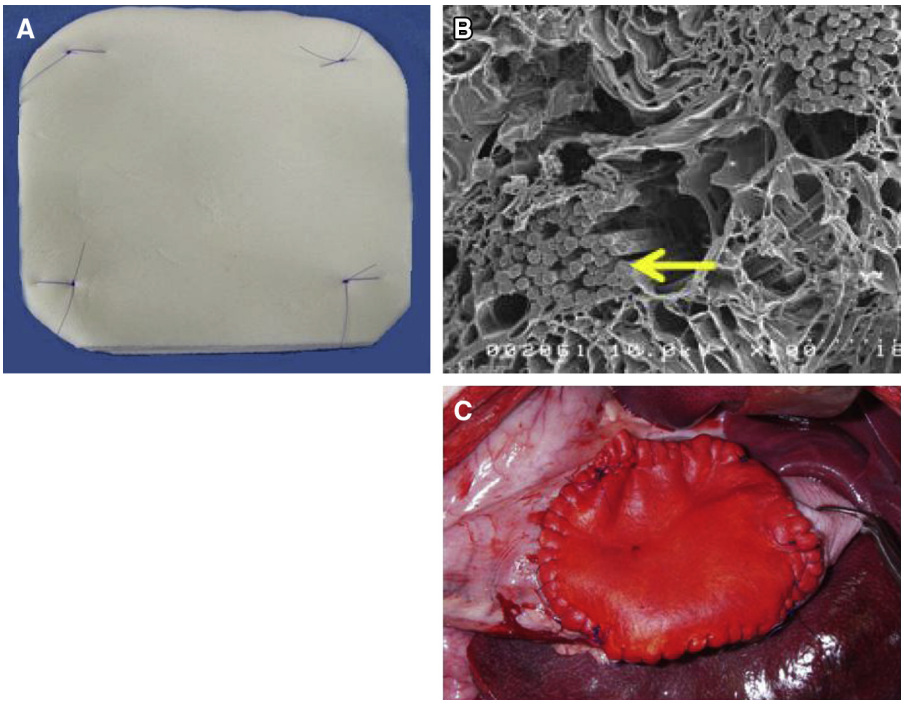

Fig 1. Creation of the artificial gastric wall (AGW). *A*, The AGW is composed of 3 bioabsorbable polymer (BAP) sheets. *B*, The BAP, in turn, is composed of copolymer fibers comprised of 50% lactic acid and 50% caprolactone and reinforced with polyglycolic acid fibers (*yellow arrow*). *C*, An 8 × 8-cm segment was resected from the anterior wall of the pig gastric corpus, and the AGW was implanted at the resected site. (Color illustration of figure appears online.)

MATERIALS AND METHODS

Creation of the AGW. To regenerate a resected area of the stomach without deformation, we created an AGW with a BAP made from copolymer fibers composed of 50% lactic acid and 50% caprolactone and reinforced with polyglycolic acid fibers (Gunze, Kyoto, Japan; Fig 1, *A*). The meshlike structure of these polyglycolic acid fibers prevents tearing even when the sheet is pierced repeatedly by a surgical needle. Likewise, the sheet remains fully intact and unbroken when gripped with surgical tweezers or when handled with endoscopic forceps. As a material originally created for vessels and bile ducts, the polymer sheet was designed with a thickness of only 1 mm (Fig 1, *B*). Because the thickness of the native stomach was approximately 3 mm, three BAP sheets were layered to prepare an AGW.

Animal surgery. This study was conducted using crossbred female pigs aged 1–2 years and weighing 20–30 kg ($n = 15$; Suzuki Farm, Saitama, Japan). After implanting the AGW into an extensively resected section of the stomach, we examined whether the graft supported tissue regeneration and whether the regenerated stomach as a whole exhibited deformation or constriction. The study was approved by the Animal Experimentation Ethical Committee of Saitama Medical University (Saitama Medical University Animal Research Protocol) and the animals were treated in conformity with the National Institutes of Health guidelines. Operations, which were performed after a 12-hour fast, were commenced by restraining the animal, administering an intramuscular injection of ketamine hydrochloride (10 mg/kg), and inserting an endotracheal tube with the animal fixed in a supine position. General anesthesia was administered by continuous inhalation of sevoflurane (2–3%) while maintaining respiration by mechanical ventilation. After sufficiently disinfecting the abdomen with povidone iodine, the stomach was exposed via an epigastric midline incision. An 8 × 8-cm^2 (approximately one-half of the circumference of the porcine central gastric corpus) section of the anterior gastric wall was resected using an electric scalpel, and an oval AGW patch of the same size was running sutured with a 4-0 PDS (Ethicon, Johnson & Johnson, Livingston, Scotland, UK) absorbent thread to close off the resected area (Fig 1, *C*). The pigs were allowed to ingest water and liquid food at 12 or 24 hours after surgery. The chow diet provided before implantation was resumed after 72 hours. H2-blockers or proton pump inhibitors were not mixed in the