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Cartilage suspension using a poly (lactic-*co*-glycolic) acid system

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Summary *Background:* This study aims to determine whether a bar-like implant made of poly lactic-*co*-glycolic acid (PLGA) could be used for cartilage suspension and whether the implant would be suitable for rhinoplasty.
Methods: Three types of *in vivo* animal experiments were performed. First, the ear cartilage was incised in a full-thickness pattern, and the PLGA system was placed between the upper and lower cartilage to offer support to the tissue. Second, after the ear cartilage was forcibly bent, an implant was placed in the cartilage. For these rabbits, the outer aspect of the ear cartilage was assessed at 2, 4, 8, 10, and 12 weeks postoperatively. In addition, tissue samples were collected for histological evaluation 12 weeks after surgery. Third, the bar-like nasal implant was used for nasal septal suspension. We obtained micro-computed tomography (CT) images and evaluated the inflammatory reaction at 12 weeks postoperatively.
Results: The results of both the ear suspension and bending retention tests revealed that the characteristic shapes of the cartilage were well preserved at 12 weeks postoperatively. Moreover, no abnormal inflammatory reaction was present in any site in the experimental group. We successfully implanted the bar-like nasal implant in the rabbit's septum, and no complications occurred. Furthermore, the physical examination and the micro-CT images did not reveal any nasal obstruction or inflammation.
Conclusions: We confirmed that an implant made of PLGA can be maintained in the cartilage tissue and believe that this can be applied in rhinoplasty as an alternative to autologous cartilage.

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Introduction

In rhinoplasty, various biological and nonbiological materials are used for dorsal augmentation, while nasal tip plasty often uses autologous cartilage grafts that have been widely used until today. The tip plasty is important in determining the overall shape of the nose. Therefore, many studies have been conducted on developing good techniques for performing nasal tip plasty.[1–4] Septal cartilage and ear cartilage are the standard materials used because of their low risk of scarring upon harvesting. However, the use of an autologous cartilage graft has disadvantages such as difficulties in harvesting, limited amount of available tissue, and long-term deformities (deformation or collapse of the L-strut).[5–8] In the Asian population, harvesting firm and sufficient cartilage is particularly difficult, given the septal cartilage is small and weak, especially in patients with a short nose.[9,10] Furthermore, it proves even more difficult to harvest enough cartilage in cases of secondary rhinoplasty. In such instances, surgeons could harvest the costal cartilage or use an allograft. Furthermore, they should consider the risk of scarring of the chest, and that the grafted cartilage might be hard and could be absorbed and bent.

However, if a biocompatible material is used during rhinoplasty, the harvest time would be reduced and the rate of donor site morbidity would decrease. In addition, the time spent procuring an allograft, the financial implications of the surgery, and the risk of complications could be reduced. Therefore, the authors tried to determine whether a bar-like implant made of poly (lactic-*co*-glycolic acid) (PLGA) could be used for cartilage suspension and thus for rhinoplasty.

Materials and methods

Implants

The bar-like implant used in this experiment was made of PLGA. The polymer had a lactic acid versus glycolic acid ratio of 82:18 (Glotech Co., Ltd., Gyeonggi-do, Republic of Korea). The shape of the implant was altered to match the biological assessment of each of the experiments (Figure 1).

Animals

Following the approval from the Seoul National University Bundang Hospital (reference code IACUC #BA1202-099/010-01), 20 male New Zealand white rabbits weighing from 2.5 kg to 3.0 kg were used in this study.[11–15] The animal laboratory staff examined the animals on a daily basis for evidence of adequate feeding and activity and for signs and symptoms of distress. The animals were randomly divided into three groups corresponding to the three types of *in vivo* tests.

Surgical procedures

The surgical procedures were performed under anesthesia using a mixed solution (Zoletil to Xylazin ratio of 1:1; 0.6 mg/kg, intramuscularly). In addition, 1% lidocaine was injected to reduce pain. Once the rabbits were anesthetized and before performing the surgery, the skin was shaved and cleaned with betadine and 70% ethanol solution. At 12 weeks postoperatively, euthanasia was performed by intravenous administration of 40 mg/kg ketamine. The study consists of three experiments: ear cartilage suspension test (5 rabbits), ear cartilage bending retention test (5 rabbits), and nasal septal suspension test (10 rabbits) (Figure 2).

Ear cartilage suspension test

For this experiment, we used five rabbits. After creating a transverse incision of approximately 3 cm in length in the outer skin of both ears each rabbit, the cartilage was incised in a full-thickness manner (Figure 3). On the one side, the bar-like implant was placed between the upper and the lower parts of the incised cartilage to support it (Figure 1a). No suture or fixation was used. The outer skin was sutured by using 4-0 Nylon® (WOORHI Medical, Korea). On the other side, the cartilage was sutured with biodegradable 3-0 Vicryl® (ETHICON, Europe) after incision of the cartilage. The outer skin was also sutured with Nylon®. The angle of the ear cartilage was measured 2, 4, 6, 8, and 12 weeks postoperatively. Twelve weeks after the surgery, tissue samples were collected for the histological evaluation.

Ear cartilage bending retention test

The outer skin and cartilage of the ears of another five rabbits were incised for this test. After the lower portion of the cartilage (about 1 cm × 1 cm in size) was forcibly bent, an implant (Figure 1b) was positioned into the cartilage of one ear. After inserting the implant, the skin was sutured by using 4-0 Nylon® (Figure 4). On the other side, we bent the cartilage in the same manner and sutured it with 3-0 Vicryl®. We evaluated the ears for skin changes (inflammation) such as redness and swelling and checked the contour by touching the ears 2, 4, 6, 8, and 12 weeks after the surgery. In addition, tissue samples were collected 12 weeks after the surgery for the histological evaluation.

Nasal septal suspension test

Ten rabbits were used for this test. After sterilization with 3% betadine solution, 2% lidocaine was injected into the nasal bone area. A vertical incision was made along the midline. When the nasal bone was exposed, medial osteotomy was performed between the nasal bones using a Joseph knife. After straddling both sides of the nasal bone, the nasal septal cartilage was identified. The septal cartilage was detached from the mucoperichondrium by using a freer elevator. This specific step of the surgery required additional attention to ensure that the mucous membranes did not tear and that the nasal cavity was not exposed. We did not perform additional scoring or removal of septal cartilage. We inserted the implant with two parallel arms, and it was held on both sides of the septal cartilage. A prepared bar-like nasal implant was secured to the septal cartilage using a nonabsorbable suture material (Figures 1c and 5). The fascia and the skin were sutured in one layer using Nylon®. After the operation, 5 mg/kg of gentamicin was injected into the thigh muscles, and no additional antibiotics were administered. We closely monitored the nose and the nasal cavity condition for 12 weeks by using micro-