Pressure Necrosis of Septal Cartilage Associated With Bilateral Extended Spreader Grafts in Rhinoplasty

Dong-Hak Jung, MD, PhD; Geun-Uck Chang, MD; Lei Shan, MD; Da-Lie Liu, MD; Zhi-Jun Wang, MD; Hong-Jun Tian, MD; Can Chen, MD; Wade W. Han, MD

Objective: To investigate septal cartilage compressive changes as a result of bilateral extended spreader grafts (ESGs), which are commonly used in rhinoplasty. The buckling, rupturing, or necrosis of the recipient site leads to nasal tip structural deformity. These pathologic changes associated with bilateral ESGs warrant the clinician’s attention and in-depth basic and clinical research.

Methods: The basic experimental study involves New Zealand rabbits, randomly assigned to groups A, B, C, and D, with group A as a reference. The right auricular cartilage was harvested and transplanted into a corresponding anatomic location of the left ear. The compressive effect was studied by gross observation and microscopic examination with hematoxylin-eosin staining after 3 months. In a clinical experiment, revision rhinoplasty surgical procedures were performed in 10 human patients 6 months to 1 year after placement of bilateral ESGs. The compressive changes of septal cartilages between the ESGs were observed intraoperatively.

Results: In group A of the rabbits, no pathologic change was noted, but 2 cases of attenuation were observed in group B (33.3%), 6 cases of central fracture (100%) with 1 case of perforation (16.7%) in group C, and 6 cases of different degrees of defects in group D (100%). Clinical intraoperative observations revealed 1 case of defects and necrosis (10%), 4 cases of attenuations and cracks (40%), and 5 cases of attenuations (50%).

Conclusions: Septal cartilage compressive necrosis leading to structural damage by bilateral septal ESGs is a clinically significant complication of rhinoplasty. Owing to its affect on the viability of the original septal cartilages, we believe the unilateral ESG with columellar strut is preferred, especially in Asian patients.

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Traditionally, in Asian patients, bilateral extended spreader grafts (ESGs) are widely used to provide nasal tip support, to improve nasal tip projection, and to control nasal shape, particularly in the treatment of contracted noses. It is a common view that the bilateral ESG provides more postoperative stability and reliability than the unilateral spreader graft. The clinical problems associated with bilateral ESGs are widening of the nasal vault, stiffness at the transition between the nasal tip and anterior nasal septal angle, and possible internal nasal valve obstruction. Our clinical observations led us to discover that in Asian patients, owing to the weakness of nasal septal cartilages, wider bilateral ESGs could cause ischemic necrosis and thus structural damage to the original septal cartilages. This is a clinically significant complication observed in revision rhinoplasty. We have treated many contracted noses with tight soft-tissue envelopes that require strong ESGs for support. In the past, we typically used strong bilateral ESGs to lengthen and widen the nasal tip (Figures 1, 2, 3, and 4). Because of the septal ischemic necrotic changes with loss of rigidity, reestablishing nasal tip support is very difficult (Figure 5). To further understand this clinical dilemma and to improve our surgical outcome, we designed our basic laboratory studies and clinical case observations to validate our hypothesis.
Twenty-four adult New Zealand rabbits of both sexes were divided into 4 groups (A, B, C, and D), with 6 in each group. The harvesting sites were located at normal auricles approximately 5 cm from the helical roots, avoiding blood vessels, through longitudinally oriented “U” incisions.

In group A (the reference group), a portion of auricular perichondrium measuring $15 \times 5$ mm was elevated off the left auricular cartilage and then sutured back onto its original location. In group B, a piece of auricular cartilage measuring $15 \times 5$ mm was harvested from the right ear. The corresponding left ear skin and perichondrium were incised, and the perichondrium was elevated; the graft was implanted in the pocket between the perichondrium and the cartilage, then sutured for stability. The perichondrium and
skin were then closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6). In group C, 2 pieces of auricular cartilage measuring 15 x 5 mm were harvested from the right ear. The bilateral perichondria were elevated in the left ear, and the grafts were transplanted into bilateral subperichondrial pockets, 1 on each side. All 3 layers were brought together with sutures, and the wound was closed in layers (Figure 6).
closed in layers. In group D, 2 pieces of auricular cartilage measuring 15 × 10 mm were harvested from the right ear. The graft implantation procedure was the same as described for group C.

The transplanted graft materials were removed 3 months later. The remaining original recipient auricular cartilages were removed from the animals and studied by gross observation (for shape, color, texture, elasticity) and microscopic examination (hematoxylin-eosin staining, original magnification ×40) with an Olympus BH-2 optical microscope (Olympus Optical Co Ltd, Tokyo, Japan).

RESULTS

GROSS STUDIES

In group A, the external appearances were normal. The cartilages showed no changes in color or texture. In group B, it was possible to separate the grafted and original recipient cartilage. The original cartilages were slightly darker in color and without any necrosis. In group C, adhesions between graft and original recipient cartilages were noted. The original cartilages were darker, weaker, thinner, and more brittle. Central cracks and fractures were noted in all 6 original cartilages. One perforation was noted to be quite regular in shape with intact periphery. In group D, we noted severe adhesions between the graft and recipient cartilages and had considerable difficulty in separating them. When the cartilages were separated with force, fractures were noted.

The skin and perichondria were thickened. The original cartilages were attenuated with lucidity and transparency. They were twisted and deformed, with irregular surfaces, brittle, and easily broken into pieces. All 6 original cartilages had defects to varying degrees, near the distal auricular rims, in sizes about 2 × 3 mm and with various perforation shapes and sizes (Figure 7) (Table 1).

HISTOLOGIC STUDIES

In group A, the recipient cartilaginous cells were well organized and aligned without nucleic changes. The intercellular matrix and cytoplasm were could be seen with normally colored hematoxylin-eosin staining. The collagen fibers were well organized. The recipient cartilaginous cells in group B were irregular in their organization and alignment with nucleic contraction and dissolution at the compressed portion. The intercellular matrix and cytoplasm appeared to stain more lightly. Collagen fibers were relatively well organized. The recipient cartilaginous cells in group C were haphazard, with lighter intercellular matrix and cytoplasm. Necrotic zones were noted on the bilaterally compressed region. Nucleic breakage and dissolution were also noted. The collagen fibers were disorganized. In group D, large areas of necrosis were noted within the original recipient cartilage, without any intact zones. Most cartilaginous zones were calcified, and cells were haphazard, in various shapes. Very poorly stained intercellular matrix and cytoplasm were seen. The collagen fibers were disorganized (Figure 8).

CLINICAL EXPERIMENT

From January 2004 to October 2008, 10 patients receiving bilateral ESGs in rhinoplasty and then undergoing revisions were evaluated. They were all women (mean age, 32 years; range, 22-47 years) with contracted noses. Two were treated with autologous septal cartilage grafts, 7 with autologous rib cartilage grafts, and 1 with cadaveric cartilage grafts. All patients subsequently underwent revisions after 6 to 12 months. The original septal cartilages were closed and observed under direct vision intraoperatively. Of the 10 original cartilages observed, necrosis with rupture was noted in 1 case, attenuation with perforation in 4 cases, and attenuation with lucidity in 5 cases (Table 2).

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<thead>
<tr>
<th>Septal Cartilage Condition</th>
<th>New Zealand Rabbit Group, No. (%)</th>
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<tbody>
<tr>
<td>Necrosis and perforation</td>
<td>0 0 1 (16.7) 6 (100)</td>
</tr>
<tr>
<td>Attenuation and dehiscence</td>
<td>0 0 6 (100) 6 (100)</td>
</tr>
<tr>
<td>Attenuation</td>
<td>0 2 (33.3) 6 (100) 6 (100)</td>
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Table 1. Experimental Study: Pressure Causing Damage or Loss of Septal Cartilage Associated With Bilateral Extended Spreader Grafts
According to the nasal tip theory of Byrd et al., ESGs could significantly influence the projection and rotation of the nasal tip. The ESGs are often applied in pairs in Asian patients because of the advantages of good symmetry and enhanced tensile strength. Unilateral use of the graft provides a weaker support, correcting nasal deviation with less symmetry or stability than bilateral ESGs. Our clinical observations revealed that bilateral ESGs cause compressive pathologic changes at the recipient septal cartilages. They often become thinner, weaker, and develop cracks, fractures, and necrosis, resulting in deformities. This is a clinically significant complication with bilateral ESGs. The affected septal cartilage weakens support to the grafts in the long run and thus reverses the initial purpose of the bilateral ESGs. The blood supply to the septal cartilage derives mainly from bilateral perichondria. Following the elevation of the perichondria off the cartilage, the nutrient reaches the cartilage only by diffusion of tissue interstitial fluid. The ESG provides a structural barrier to this diffusion process. The larger the barrier area, the less the nutrient penetration to the cartilage, and the more likely that ischemic changes will develop.

Naficy and Baker described nasal tip grafting techniques to lengthen a short nose, with the bilateral ESG being very predictable and effective. Owing to the weakness of Asian septal cartilage, bilateral ESGs are popular. The tensile strength of Asian septal cartilage is less than that of the cartilage of white individuals and provides insufficient resistance to tight pressure, and thus the cartilage is more prone to necrosis and perforation. Second, the donor septal cartilages are thinner and weaker, and thus larger grafts with broader surface areas are often needed, leading to less contact between recipient septal cartilages and their perichondria, further increasing the chance of ischemic necrosis.

Table 2. Clinical Study: Pressure Causing Damage or Loss of Septal Cartilage Associated With Bilateral Extended Spreader Grafts

<table>
<thead>
<tr>
<th>Septal Cartilage Condition</th>
<th>Cases, No. (%)</th>
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<tr>
<td>Necrosis and rupture</td>
<td>1 (10)</td>
</tr>
<tr>
<td>Attenuation and dehiscence</td>
<td>4 (40)</td>
</tr>
<tr>
<td>Attenuation and lucidity</td>
<td>5 (50)</td>
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Through basic laboratory experiments, we discovered that unilateral implantation of 5-mm-wide autologous auricular cartilage graft did not cause any clinically significant pathologic changes 3 months after surgery. However, bilateral placement of 5- and 10-mm-wide cartilage grafts led to clinically significant recipient pathologic changes. In the group with 10-mm grafts, histologic necrosis was noted in up to 100% of the cases, and larger gross defects were also noted. This was consistent with our clinical observation of pressure necrosis in bilateral ESG applications. This is especially important when dealing with the weaker donor cartilages found in Asian patients when trying to achieve predictable postoperative structural stability and optimal aesthetic outcome. Other factors, such as areas of bilateral perichondrial elevations, suturing techniques, and the number of sutures used, as well as possible postoperative septal hematoma, can also influence the surgical results. Our experience with Asian patients has shown excellent results with unilateral ESG. To overcome its tendency to deviate, we often combine the unilateral ESG with a columellar strut. By suturing these graft materials in the opposite curvature or orientation, the surgeon can fix the ESG and columellar strut to the midline, with minimal postoperative risk of deviation (Figure 9 and Figure 10). The combination also solidifies the nasal tip, providing a desirable surgical outcome.

![Figure 9. Unilateral extended spreader graft (ESG) (unilateral wide ESG and columellar strut). A, Schematic diagram. B-D, Intraoperative views of unilateral wide ESG and columellar strut.](image)

![Figure 10. Preoperative and postoperative views of a representative patient. A and B, Frontal views; C and D, lateral views; and E and F, three-quarter views.](image)
Through laboratory studies and clinical observations, we conclude that bilateral ESGs can put compression onto the septal cartilage at the recipient site, resulting in pressure ischemic changes and structural deformities. This is a clinically significant complication associated with bilateral spreader grafts in rhinoplasty. We suggest using a smaller graft when possible. Moreover, by alternating anterior and posterior orientation on each side of bilateral ESGs, the reduced overlapping area of 3 cartilages will help preserve the nutrient supply to the septal cartilage. If a wider ESG is needed when using a weaker graft material, a large unilateral ESG in combination with a columellar strut provides a satisfactory outcome. Our current understanding of the fate of the nasal septal cartilage in rhinoplasty is still very limited, and future basic laboratory and long-term clinical studies are necessary.

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Correspondence: Dong-Hak Jung, MD, PhD, Shim-mian Rhinoplasty Clinic, 211, Seocho Hyundai Tower, 1319-13, Seocho-dong, Seocho-gu, Seoul 137-070, South Korea (doctorshanlei@gmail.com).

Author Contributions: Study concept and design: Jung, Shan, Liu, and Wang. Acquisition of data: Jung, Chang, Tian, and Chen. Analysis and interpretation of data: Jung, Shan, and Han. Drafting of the manuscript: Jung, Chang, Shan, Liu, Wang, Tian, Chen, and Han. Critical revision of the manuscript for important intellectual content: Jung. Statistical analysis: Jung. Obtained funding: Jung. Administrative, technical, and material support: Jung, Chang, and Shan. Study supervision: Jung.

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REFERENCES