

Harvesting the Entire Seventh Costal Cartilage for Secondary Rhinoplasty

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Background: As rhinoplasty is becoming increasingly common, the number of revision cases is also increasing. These cases require more cartilage, and costal cartilage is considered a good material. We introduce a method of harvesting the entire seventh costal cartilage.

Methods: This study was performed from April 2019 to March 2020. The seventh costal cartilage was harvested from 156 patients. The incision was placed at the inframammary fold in women and directly above the cartilage in men. The length of incision was approximately 3.5 cm. After skin incision, we found a muscle fascia plane, and wide dissection was performed. We opened the muscle fascia and split the rectus abdominis muscles. Then, the seventh costal cartilage was exposed. Careful subperichondrial dissection was continued circumferentially. After the posterior aspect of the cartilage was exposed, the costochondral junction was cut and dislocated. The remaining perichondrial dissection was performed under direct vision to avoid violating the perichondrium. Then, we dislocated the synchondrosis between the sixth and seventh cartilages and the seventh and eighth cartilages in turn. Finally, we cut the sternocostal area while protecting the underlying perichondrium and removed the cartilage. We checked for pneumothorax and then closed the wound layer by layer using 2-0 and 3-0 Vicryl sutures. Skin closure was performed with Steri-Strips.

Results: The mean time for cartilage harvesting was 52 minutes. The average length of the cartilage was 9.33 mm. No cases of pneumothorax or postoperative morbidities were noted.

Conclusion: We used sufficient amounts of cartilage to perform satisfactory rhinoplasty. (*Plast Reconstr Surg Glob Open* 2022;10:e4510; doi: 10.1097/GOX.0000000000004510; Published online 20 September 2022.)

INTRODUCTION

An increase in rhinoplasty procedures has resulted in an increase in revision rhinoplasty. The success of revision rhinoplasty depends on the integrity of the internal cartilage structure.^{1,2} The use of costal cartilage to solidify this structure is inevitable. It is often impossible to use the ear and septal cartilage because they were used in the previous surgery.

The use of costal cartilage, which involves a region of cartilage harvest other than the nose, leaves an additional scar on the chest. The procedure requires general

anesthesia and extended surgery time, which burdens both patients and surgeons. Recently, methods to harvest cartilage from small incisions have been introduced, reducing scarring and surgical time, thus reducing these concerns.³⁻⁶

This is a desirable method of improvement; however, if the nose is short or contracted with alar retraction or other deformities, a large amount of cartilage is needed for correction. We operated on these cases using spreader, columellar, dorsal onlay, lateral crural strut, rim, batten, premaxillary, paranasal, and tip grafts.

These grafts are all autologous; therefore, substantial amounts of cartilage are required.⁷ Therefore, we used the entire cartilage of the seventh rib.

Previous published articles have introduced harvest methods that yield less cartilage than this procedure.^{4,6,8} More options are needed to harvest large amounts of cartilage, such as that obtained using our method. Concerns about deformities after harvest are also noted. Therefore, we introduce our method for harvesting the entire seventh rib cartilage to minimize morbidity.

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MATERIALS AND METHODS

Study Subjects

This study was planned retrospectively and performed from April 2019 to March 2020. Patient charts and photographs were reviewed according to the guiding principles of the Declaration of Helsinki. There were 156 patients, including 37 men and 119 women. The inclusion criteria were revisional rhinoplasty patients who underwent spreader, columellar, and dorsal onlay grafts using total seventh costal cartilage. The exclusion criteria were patients who had minor revisions, such as tip or rim grafts that did not correct the L-strut. In principle, the right seventh costal cartilage was used. However, in 28 patients for whom the right seventh costal cartilage was used in previous operations, the left seventh costal cartilage was used. We described the procedure of cartilage harvesting, and the data reviewed included the time of harvesting, length and thickness of the harvested cartilage, and morbidity of harvest site. We measured the size of the cartilage used in the grafts. Finally, we determined how much cartilage we needed.

Design of Incision Site

The incision was placed at the inframammary fold line in women and directly above the cartilage in men. In women, we found the inframammary fold line in a sitting position and ensured that the scars were camouflaged sufficiently. The incision started where the vertical lines of the nipple complex and inframammary fold line met and went outward. If the patient planned to undergo breast augmentation surgery later, the incision lines were set accordingly. At this time, we set Randquist's formula as a reference (Fig. 1).⁹ In men, the incision was located on the upper border of the seventh costal cartilage, and it was parallel and middle third to the connecting line between the sternum and the seventh rib. There was no structure

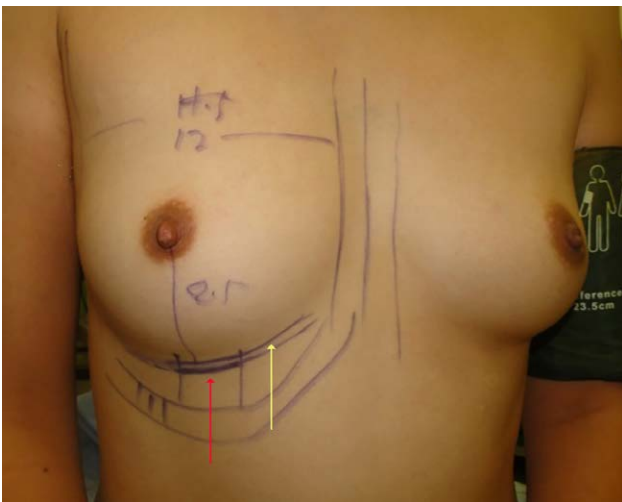


Fig. 1. Design of incision site. In female patients, the incision line is basically defined as the inframammary fold line (yellow arrow) in the sitting position. If patients intend to undergo breast augmentation later, Randquist's formula is used (red arrow).

Takeaways

Question: How much cartilage is needed to create a strong internal structure in revision or secondary rhinoplasty, and how do we harvest a safe and sufficient amount of costal cartilage?

Findings: The spreader grafts averaged 33.89 mm, the columellar grafts averaged 27.18 mm, the dorsal onlay grafts averaged 37.64 mm × 9.56 mm × 3.79 mm, and the alar rim grafts averaged 26.59 mm. Tip grafts were triangular in shape, and the length of one side averaged 13.03 mm.

Meaning: An average of 9.3 cm of costal cartilage was harvested and used, and the entire seventh costal cartilage was harvested to firmly reconstruct the internal cartilage structure.

for camouflage, in contrast to that noted for women, so close incision simplified the harvest. The same procedure was performed using the left seventh costal cartilage. The length of the incision was approximately 3.5 cm.

Surgical Technique

All procedures were performed under general anesthesia. Local anesthetic solution was administered at the incision line and inferior borders of the seventh costal cartilage for hemostasis of intercostal vessels. The anesthetic solution consisted of 1% lidocaine with 1:100,000 epinephrine. The skin incision was made using a no. 15 blade. The subcutaneous tissue was dissected using electrocautery until the muscle fascia plane was reached. We found the muscle fascia plane and palpated the underlying seventh costal cartilage. Wide dissection was performed over the seventh costal cartilage area between the sternocostal junction and the costochondral junction. We opened the muscle fascia along the seventh costal cartilage superior border. Next, we found the aponeurosis between the rectus abdominis and external oblique muscles. These muscles were split using blunt Metzenbaum scissors and retracted superiorly and inferiorly with Army-Navy retractors. Then, the seventh costal cartilage was



Fig. 2. The dissection process. The rectus muscle fascia plane is observed, and one can palpate the seventh costal cartilage. After opening the rectus muscle fascia, aponeurosis between rectus abdominis muscles and external oblique muscles is noted. This area is split to identify the seventh costal cartilage.

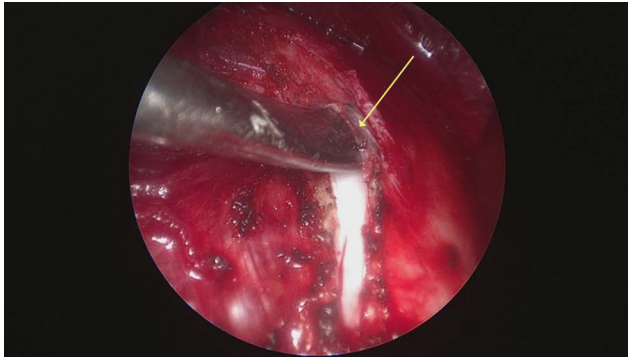


Fig. 3. Exposure and dissection along the seventh costal cartilage. A longitudinal incision was made through the superior border of the perichondrium. Dissection was started on the anterior portion of the costal cartilage. During dissection, be careful not to leave the perichondrium (yellow arrow). Dissection to the inferior border of the cartilage prevents intercostal vessel injury and bleeding.

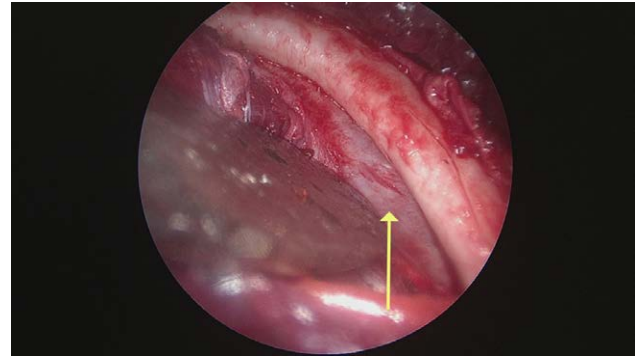


Fig. 5. Dissection on the posterior portion of the cartilage. It is important to peel off using the flip-away method. Care was taken not to damage the posterior perichondrium (yellow arrows). If it is injured, there is a high probability of pneumothorax.

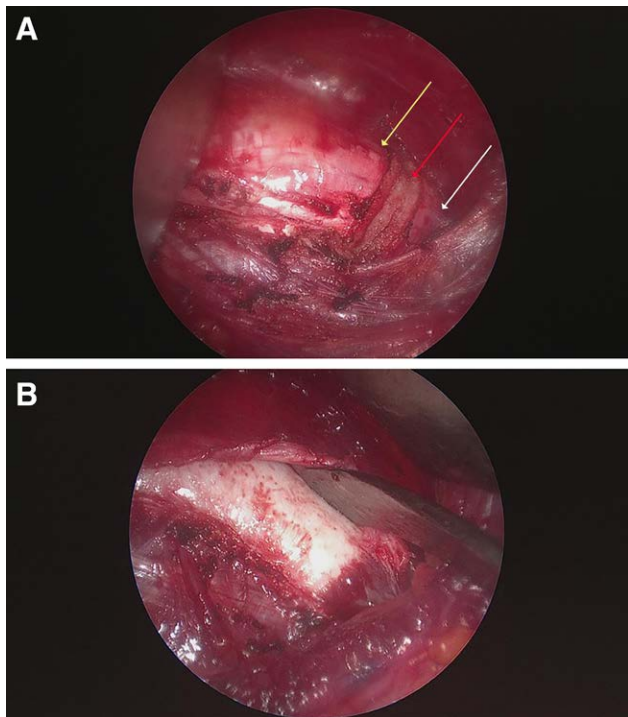


Fig. 4. The costochondral junction between the seventh rib and cartilage. A, There is a cartilage (yellow arrow), seventh rib (white arrow), and perpendicular cut of the perichondrium (red arrow). B, Dissection was performed at the inferior border of the cartilage.

exposed (Fig. 2), and dissection was performed until the junction of the sternum and the seventh rib was reached.

After exposing the seventh costal cartilage, a longitudinal incision was made through the superior border of the perichondrium using electrocautery. Careful subperichondrial dissection was continued circumferentially (Fig. 3). First, the anterior part of the costal cartilage was dissected from the synchondrosis between the sixth and seventh costal cartilage to the costochondral junction using a periosteal elevator. We were careful not to damage the cortex by using a tool that was too sharp. The

dissection was performed until reaching the inferior border. Second, a perpendicular cut of the perichondrium was made at the costochondral junction using electrocautery on the rib side (Fig. 4). The costochondral junction can be easily found because the color changes from white to reddish gray. After the perichondrium was detached, additional dissection was performed at the inferior border of the costochondral junction (Fig. 4). Third, the posterior part was dissected. Periosteal elevators were used to release the posterior adherence between the synchondrosis and the costochondral junction.

It was important not to poke but to peel off (Fig. 5). Given the lack of direct vision at this point, the posterior part of the perichondrium could be damaged. Fourth, after the posterior portion of the cartilage was exposed, the costochondral junction was cut and dislocated. We ensured that the posterior part and inferior border of the dissection had been penetrated. We supported the posterior part of cartilage using periosteal elevators to prevent injury to the perichondrium and used a no. 15 blade to cut the cartilage. The superior part could be cut to full thickness; however, the inferior part could be cut only anteriorly to avoid damaging the intercostal vessels. We used periosteal elevators to completely cut the cartilage and lifted the cartilage to dislocate it (Fig. 6). Then, the posterior part of the cartilage was visible. It was more visible upon lifting the cartilage using the elevator on the left hand, and the remaining posterior part of the cartilage was dissected safely. Next, the synchondrosis area was separated. After dislocation of the costochondral junction, a gap was formed, making it easy and safe to dissect. We separated the synchondrosis between the sixth and seventh costal cartilage and between the seventh and eighth costal cartilage one by one. At this time, unlike traditional perichondrium, there was a fibrous component of tissue.¹⁰ If necessary, this component should be clearly cut using electrocautery. If this tissue is not sufficiently cut, it could cause damage to the perichondrium during dissection (Fig. 7). Finally, we cut the sternocostal area while protecting the underlying perichondrium using a periosteal elevator. Using a no. 15 blade, we cut the cartilage to prevent damage to the surrounding tissue and perichondrium. We placed a

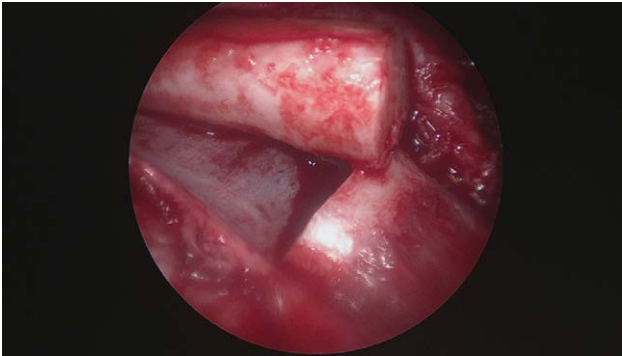


Fig. 6. The costal cartilage is cut and dislocated on the costochondral junction. The subperichondrial dissection plane is penetrated between the posterior part and inferior border. The cartilage is cut while protecting the posterior perichondrium. The cutting depth of the cartilage is different. It is full thickness on the superior part, and it does not include the posterior cortex on the inferior border, which prevents damage to intercostal nerves and vessels. It is dislocated on the costochondral junction so that the posterior perichondrium is visible.

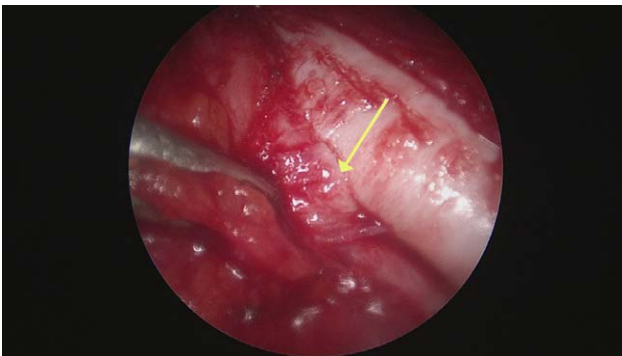


Fig. 7. Dissection on the synchondrosis area. A fibrous component of tissue on synchondrosis (yellow arrow). Care is needed when dissecting. The posterior perichondrium is easily torn, which causes pneumothorax. So, it is imperative that fibrous component of tissue on synchondrosis is detached. In case of damage, since the perichondrium is preserved and not ripped off, it is easy to repair by suturing the posterior perichondrium.



Fig. 8. The cartilage is removed after cut and dislocation. This is after cartilage is harvested; it is in the direction of the rib. There was no tearing or injury on the posterior perichondrium.

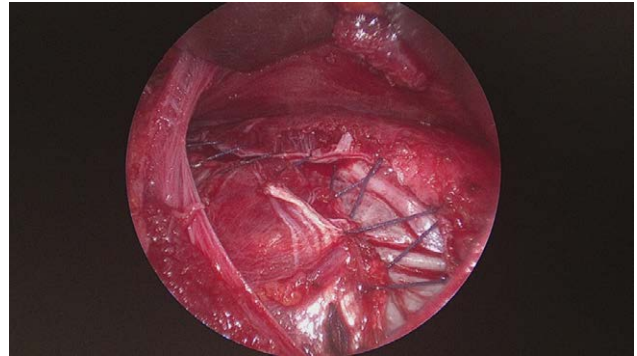


Fig. 9. Reducing the dead space using sutures. The remaining perichondrium is sutured to decrease dead space. When it is performed, the eighth cartilage, which is floating cartilage, is moved superiorly to reduce dead space.

finger in the sternocostal area to determine whether it was cut well. Then, we removed the cartilage after dislocation (Fig. 8). Usually, we obtained the anterior part of the perichondrium used in rhinoplasty for camouflage or preventing revelation of the dorsal graft.

We filled the wound with saline solution and checked for pneumothorax by applying positive pressure to the lungs. We ensured that air was not leaking. Then, the wound was closed layer by layer using 2-0 and 3-0 Vicryl sutures. We attached the eighth floating cartilage to the sixth cartilage as much as possible to minimize dead space (Fig. 9). Then, a drain was inserted in the space between the sixth and eighth cartilages so that seroma did not occur. Reapproximation of rectus muscles and oblique muscles was performed. The fascia was closed tightly to prevent herniation or other morbidities. After suturing the subcutaneous layer, the skin closure was performed using Steri-Strips.

Measurement

We recorded the entire operation time and cartilage harvest time.

The length and thickness of the harvested cartilage were measured. The length was measured from the end

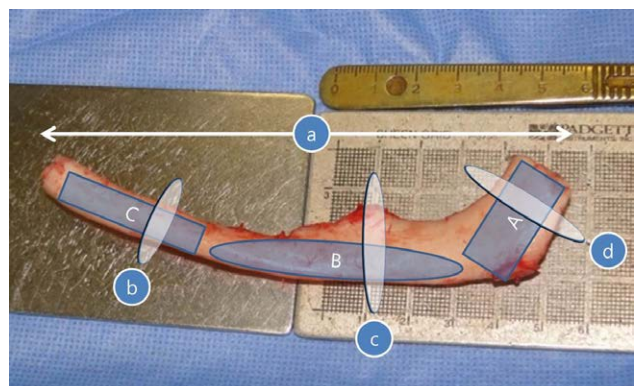


Fig. 10. Harvest and usage of cartilage. a, The length of harvested cartilage. b, Thickness of the medial side. c, Thickness of the middle side. d, Thickness of the lateral side. A, Segment for the columellar graft. B, Segment for the dorsal onlay graft. C, Segment for the spreader graft.

of the sternum side to the rib side by placing it on the grid. The thickness was measured in the anterior to posterior direction and in three locations: medial, middle, and lateral points (Fig. 10). The specimens were measured by dividing the right and left sides.

The size of the cartilage used in the operation was also measured to ensure that cartilage was used in the operation. The size was assessed based on length, width, and depth. Cartilage is generally used for spreader, columellar grafts, dorsal onlay grafts, lateral crural strut or onlay grafts, batten grafts, alar rim grafts, and tip grafts. In some cases, it was also used for premaxilla or paranasal augmentation.

We also assessed for morbidities related to cartilage harvest, including cosmetic morbidities, such as scars and chest wall deformities, and functional morbidities, such as pneumothorax and pain. The cosmetic aspect was evaluated 1 year postoperatively, and the functional aspect was evaluated 1 week postoperatively. A modified Vancouver scar scale (VSS) assessment was used for scars, and Likert scales were used for pain.

RESULTS

In all cases, nasal deformities, including a short nose and retraction, were well corrected.

The total surgery time ranged from 5 hours and 20 minutes to 6 hours and 40 minutes with an average time of 6 hours 10 minutes. The cartilage harvest time averaged 52 minutes (ranging from 43 to 80 minutes) on the right side and 67 minutes (ranging from 52 to 95 minutes) on the left side.

The harvested cartilage was 7.5–12.6 cm long (average 9.33 cm) on the right side and 5.8–11.2 cm long

(average 8.72 cm) on the left side. The average thickness was 8.10 mm at the medial side, 7.82 mm at the middle, and 8.39 mm at the lateral side on the right side. The average thickness was 8.05 mm at the medial side, 7.68 mm at the middle, and 8.32 mm at the lateral side on the left side (Table 1).

Next, the size of the cartilage used was described as length × width × depth. The spreader grafts averaged 33.89 mm × 4.91 mm × 1.31 mm, the columellar grafts averaged 27.18 mm × 7.27 mm × 3.13 mm, the dorsal onlay grafts averaged 37.64 mm × 9.56 mm × 3.79 mm, and the alar rim grafts averaged 26.59 mm × 3.73 mm × 1.00 mm. Tip grafts were triangular in shape, and the length of one side averaged 13.03 mm. The premaxilla averaged 24.13 mm × 7.51 mm × 6.47 mm, and the paranasal averaged 8.49 mm × 4.53 mm × 5.04 mm (Table 2).

Satisfactory results were also noted for morbidities. The scars were well camouflaged in the inframammary fold line. Of the 156 patients, 116 had excellent VSS scores, and 34 had good VSS scores (Table 3). Six patients were excluded from augmentation mammoplasty during the period. Chest deformities due to empty space of the removed cartilage were not found. No cases of pneumothorax were noted. The chest drain was removed the second postoperative day, and the chest pain decreased dramatically from the third day. Pain ranged from 0 to 10 (no pain to severe pain) and averaged 2.3 points (Table 4). Therefore, there was no inconvenience in activity due to pain on the seventh day.

DISCUSSION

Whether rhinoplasty is successful depends on how well the internal cartilage structure is made.^{1,2} This notion is especially true when the patient has a nose that is contracted, deviated, short, or there are other defects that require revision. For rhinoplasty to address this problem, structural rhinoplasty is essential to create the L-strut structure.^{11,12} Spreader grafts and columellar grafts are essential for structural stability.⁷ Our data show that spreader and columellar grafts need to be approximately 25–38 mm in length. These grafts are a basic part of reconstructing structures. For aesthetic purposes, additional alar rim and tip grafts are needed. A dorsal onlay graft approximately 38 mm in length is also

Table 1. The Size of Harvested Seventh Costal Cartilage

Study		Right Side	Left Side
Length (a)	Range (min–max)	7.5–12.6 cm	5.8–11.2 cm
	Mean	9.33 cm	8.72 cm
Thickness (b)	Range (min–max)	6.1–9.5 mm	6.1–9.4 mm
	Mean	8.10 mm	8.05 mm
Thickness (c)	Range (min–max)	6.0–9.3 mm	6.0–9.3 mm
	Mean	7.82 mm	7.68 mm
Thickness (d)	Range (min–max)	6.0–10.2 mm	6.0–9.9 mm
	Mean	8.39 mm	8.32 mm

Table 2. The Size of Grafts

Type of Graft		Length (mm)	Width (mm)	Depth (mm)
Spreader graft	Range (min–max)	31–38	3–8	1–2
	Mean	33.89	4.91	1.31
Columellar graft	Range (min–max)	25–30	6–10	2–4
	Mean	27.18	7.27	3.13
Dorsal onlay graft	Range (min–max)	31–43	8–11	3.5–4.5
	Mean	37.64	9.56	3.79
Alar rim graft	Range (min–max)	25–28	3–5	1.00
	Mean	26.59	3.73	1.00
Tip graft*	Range (min–max)	12–15		
	Mean	13.03		
Premaxilla augmentation	Range (min–max)	22–28	5–10	5–8
	Mean	24.13	7.51	6.47
Paranasal augmentation	Range (min–max)	8–10	4–6	4–6
	Mean	8.49	4.53	5.04

*Tip graft is triangular shape. The length refers to one side.

Table 3. Demographic Data of the Modified VSS Scores

Scar Characteristics	Modified VSS		Patients (n = 150)
Pliability	0	Normal	150
	1	Supple	0
	2	Yielding	0
	3	Firm	0
	4	Adherent	0
Height	0	Normal	150
	1	1~2 mm	0
	2	3~4 mm	0
	3	5~6 mm	0
	4	>6 mm	0
Vascularity	0	Normal	133
	1	Pink	17
	2	Red	0
	3	Purple	0
Pigmentation	0	Normal	124
	1	Slight	26
	2	Moderately	0
	3	Severely	0
Assessment Modified VSS			Patients (n = 150)
Excellent	Pliability 0, height 0, vascularity 0, and pigmentation 0		116
Good	Pliability 0, height 0, and vascularity 0-1 or pigmentation 0-1		34
Moderate	Pliability 0 or height 0, and vascularity 0-2 or pigmentation 0-2		0
Hypertrophied	Pliability 0-1 or height 0-1 and vascularity 0-2 or pigmentation 0-2		0
Keloid	Pliability 1-3 or height 1-2 and vascularity 1-2 or pigmentation 1-3		0

Table 4. Demographic Data of Chest Wall Pain

	Likert Scales (n = 156)	Patients
No pain	0	0
Hardly notice pain	1	0
Notice pain, does not interfere with activities	2	113
Sometimes distracts me	3	32
Distract me, can do usual activities	4	7
Interrupts some activities	5	4
Hard to ignore, avoid usual activities	6	0
Focus of attention, prevents doing daily activities	7	0
Awful, hard to do anything	8	0
Cannot bear the pain, unable to do anything	9	0
As bad as it could be, nothing else matters	10	0

required in most cases, especially when performing rhinoplasty on Asian patients (Fig. 11). Similar size requirements were reported in other studies.^{4,13-15} Therefore, to perform structural rhinoplasty, cartilage with a length of approximately 10 cm is required for spreader, columellar, and dorsal onlay grafts, which is why we harvest the entire seventh costal cartilage. In terms of shape, the medial and middle parts of the seventh cartilage are straight, which is advantageous for spreader graft and dorsal onlay graft, respectively. To minimize warping of the dorsal onlay graft, it is most important to use 4-5 cm of the middle straight portion. The later part is useful suitable for columellar, premaxilla, and paranasal grafts.⁷ The seventh costal cartilage is the longest and most useful for surgery because it is very straight (Fig. 10).¹⁶

In addition, cartilage loss can occur due to unexpected calcification. The presence of greater than

26% calcification was found to be meaningful calcification, which affects the operation, in 17.2% of women. Calcification occurs more often in women than men, and the incidence increases with age. Men usually develop a marginal pattern, so they are likely to undergo the operation. However, women have central and granular patterns, so their consent for operation is difficult to predict.^{17,18} Therefore, it is efficient to harvest the entire seventh costal cartilage and perform surgery. If cartilage is insufficient, additional harvesting sixth or eighth costal cartilage could be injurious and cause morbidity. The remaining medial or lateral cartilage is difficult to harvest again. And even if harvested, there is no suitable size left, so it may be inappropriate for use.

We recommend the use of costal cartilage in revisional rhinoplasty and rhinoplasty performed for Asian patients (Fig. 12). One must harvest sufficient cartilage to operate on a sturdy structure. First, the cartilage harvested must be of good quality. The most important thing to mention is the preservation of the posterior perichondrium. To preserve the posterior perichondrium, the procedure must be performed under direct vision. Thus, we performed dissection after dislocation on the costochondral side (Fig. 6). In particular, the synchondrotic parts have fibrous tissue that consists of articular capsules and interchondral ligaments (Fig. 7). Strong force is required to dissect this tissue, and this force can damage the perichondrium. Thus, synchondrosis should be thought of as a ligament and joint, and proper cauterization and dissection should be performed.^{10,19} To achieve this, we used a small periosteal elevator one after the other instead of a Doyen elevator. It is possible to recover torn perichondrium using

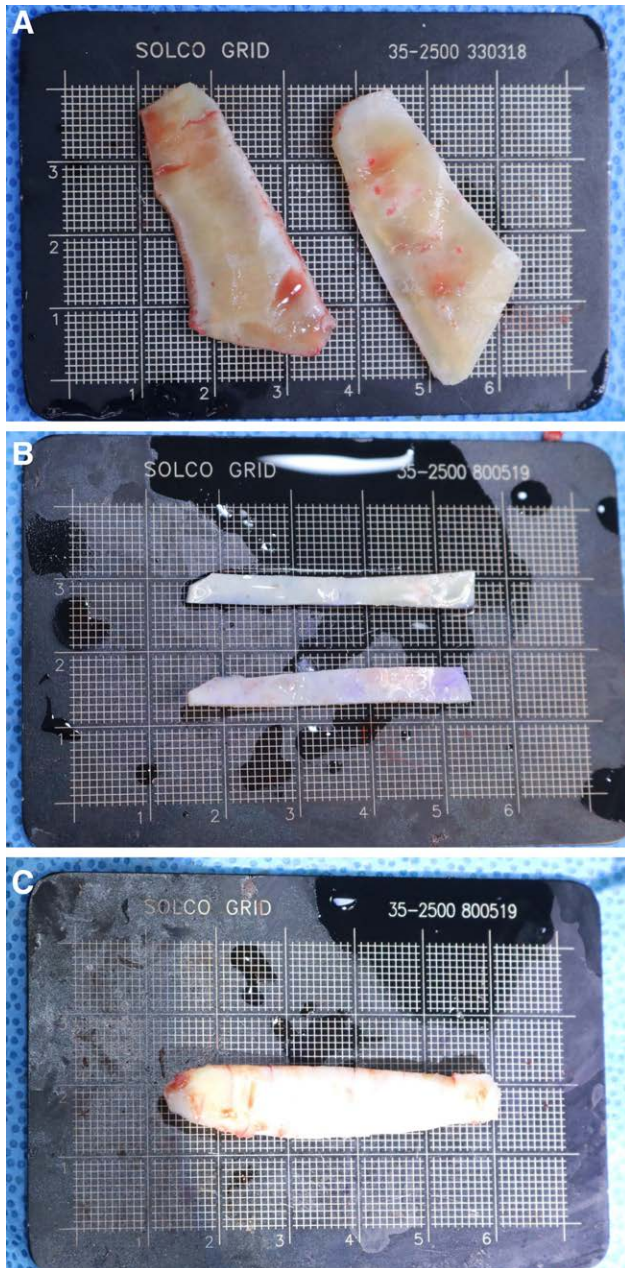


Fig. 11. Costal cartilage grafts for integrity of the internal cartilage structure. Cartilage shape for extended columnar graft (A). Cartilage shape for spreader graft (B). Cartilage shape for dorsal onlay graft. After reconstruction of L-strut structure, apply it (C).

sutures. However, if the perichondrium is torn off, it is not easy to recover because the pleural tissue is relatively weak.

Other common considerations are not crucial problems.^{20,21} Pleural tearing developed in an early case, but it resolved sufficiently during surgery. Minimal iatrogenic pleural injury that can be sutured is generally not a problem. Insert a rubber catheter into the thoracic cavity

through the slit. The wound should be closed using a purse string suture around the catheter. Then, apply positive pressure with “Valsalvas” to inflate the lungs. Subsequently, the catheter is placed on suction for negative pressure and removed while tightening the purse string suture.^{15,22,23} Therefore, it is important to leave the posterior perichondrium as described above because it needs to be sutured when pleural tearing develops. Attempts to suture the pleural tissue can induce damage. One must suture the perichondrium so that it is firmer and does not leak. If a leak occurs during surgery, postoperative chest radiographs should be taken. It is recommended to observe the patient for 2 to 3 days after surgery.^{24,25} We left dressings in place for approximately 7 days after surgery, and auscultation was performed every day.

Even if the seventh costal cartilage is completely harvested, chest deformities do not appear. With the proximal portions of the sixth and eighth cartilages in close approximation, the instability is minimal when the patient exercises. Additional cartilage is occasionally needed, and we harvest the sixth costal cartilage when half of the superior portion is taken to maintain the overall shape of the cartilage. Concerns about depression or dimpling are noted. When wounds are closed, layer-by-layer alignment is performed so that no problems occur.

Scars are unavoidable; however, we try to approach scarring as rationally as possible. The inframammary fold is used to limit scar visibility, especially in women. But, in the case of the distance from the nipple to the inframammary fold is close is different. If a patient plans to undergo breast augmentation surgery in the future, the scar will be visible. At this time, a new inframammary fold is measured and an incision is made below it according to Randquist’s formula.⁹ Sufficient explanations and predictions should be provided before the operation, so the patients are also aware of the potential for scarring.

Given the severity of these cases, pain is also reported to be more severe in the nasal area than in the chest, which is the site of cartilage harvest.²⁶ Therefore, concerns about the seventh total cartilage harvest procedure can be solved with proper management.

CONCLUSIONS

In a severely deformed nose or revisional rhinoplasty, substantial amounts of cartilage are needed for grafts to make the structure. Among the cartilages used for rhinoplasty, the seventh costal cartilage is thought to be the most effective. Therefore, the authors introduced a method to harvest the entire seventh costal cartilage.

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Fig. 12. Preoperative (A) and 3 months postoperative (B) photographs.

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