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# Batten Grafts in Patients with Valve Stenosis—Functional Outcome

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## ABSTRACT

**Objective:** The objective of this study was to find out how effective are batten grafts in improving nasal obstruction.

**Methods:** In 20 patients with alar collapse, nasal batten grafts were used. Rhinomanometry, rhinoresistometry, clinical examinations, and the Nasal Obstruction Symptom Evaluation score served as outcome measures.

**Results:** In 18 out of 20 patients, a postsurgical subjective improvement was stated, 2 patients experienced no improvement. No complications were observed. The batten grafts led to a statistically significant subjective improvement of the nasal obstruction in the Nasal Obstruction Symptom Evaluation score ($P < .001$). Rhinoresistometry did not detect the clinically present alar collapse.

**Conclusion:** Batten grafts are a simple and effective method to treat nasal obstruction caused by weakness of the lateral nasal wall.

**Keywords:** Alar collapse, batten graft, nasal valve, NOSE score, rhinomanometry

## Introduction

The internal nasal valve (INV) is a 3-dimensional construct including the nasal septum, the upper lateral cartilage (ULC), the head of the inferior turbinate, and the piriform aperture. Septum and ULC form a physiological angle of 15°-20°.[1,2] Directly adjacent to the INV, the external nasal valve is composed of the septum, the medial and lateral crura of the lower lateral cartilage (LLC), and the premaxilla.[3,4] There are primary etiologies causing constriction of the INV area, such as congenital or age-related nasal valve collapse. Secondary etiologies are comprised of nasal surgery, such as hump or septal cartilage resection and separation of the ULCs from the septum, as well as nasal trauma can cause secondary stenosis of the INV, either directly or through scarring.[5-7] A very sharp angle of the INV can cause alar collapse. The resulting stenosis leads to an increased flow velocity and negative inspiratory pressure (Bernoulli's law). If the angle is too wide, the main airflow is directed toward the nasal floor.[8] There are various conservative and surgical options to treat stenosis of the INV. Nasal plasters or dilators are examples for conservative therapy.[4]

Any form of surgical therapy is directed at structural improvement of the INV by cartilage grafts or enlargement of the space between the nasal septum and the ULC, e.g. using spreader grafts. Batten grafts are particularly useful in cases where a weak lateral nasal wall leads to alar collapse. The graft improves the stability of the lateral nasal wall, and if necessary, scar tissue can be removed. The anticipated surgical outcome is an increased stability of the lateral nasal wall and/or a widened angle in the INV region.[9,10] In 1997, Toriumi et al[10] described alar batten grafts to be a suitable, long-term treatment option for nasal airway collapse. In this study, autologous cartilage from the nasal septum or the concha was used to design the batten graft. Out of a total 46 participants, 45 reported an improvement in their nasal breathing. We aimed to study the effect of batten grafts on nasal obstruction in patients with a structural weakness of the lateral nasal wall.

## Methods

### Study Overview

In this retrospective study, patients of the Department of Otorhinolaryngology, Medical University of Innsbruck,

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meeting the inclusion criteria were enrolled in the study. Inclusion criteria comprised patients with clinically confirmed alar collapse scheduled for surgical interposition of a unilateral or bilateral batten graft. The follow-up interval was 6 months. The patients had a regular postoperative control 2 weeks and 3 and 6 months after surgery. All patients were reviewed by an experienced otorhinolaryngologist, and a detailed history was taken, including nasal symptoms, allergies, and nasal medication. Patients considered for surgery had previously failed to improve on conservative treatment (steroid spray, nasal rinsing, and nasal ointment). The assessment included nasal valve inspiration during regular and forced inspiration. Alar collapse was diagnosed when the LLC collapsed toward the nasal septum during inspiration. Patients under 18 and older than 80 years were not included. The study endpoints were the Nasal Obstruction Symptom Evaluation (NOSE) score and nasal airflow (mL/s) measured by rhinoresitometry (RRM). Furthermore, it was recorded whether additional septoplasty and/or conchotomy was performed, whether an open or closed approach was selected, and whether the batten graft was unilateral or bilateral; the donor site of the cartilage (septal cartilage or conchal cartilage) was also recorded. Written informed consent was obtained from each patient who agreed to participate in this study following a detailed explanation of the procedural workflow. Prior to any patient enrolment, the study had been approved by the institutional board in charge, the ethics committee of the Medical University Innsbruck, Austria. The respective reference number was 313/4.8.

### Nasal Obstruction Symptom Evaluation Score

The NOSE score is a validated tool for assessment of subjective nasal breathing impairment. The NOSE score was developed and validated in 2004 by Stewart and colleagues.[11] The patients answer 5 questions regarding their nasal breathing impairment preoperatively and postoperatively. The questions include (1) nasal congestion or stuffiness, (2) nasal blockage or obstruction, (3) problems in breathing through my nose, (4) sleeping problems, and (5) difficulties in breathing through the nose during exercise or physical effort. The patient can answer the questions on a 5-point Likert scale (0: no problem, 1: very mild problem, 2: moderate problem, 3: fairly bad problem, and 4: severe problem). The total score of maximal 20 points maximum and minimal 0 points minimum is possible. A high score correlates with multiple subjective problems, whereas low score points indicate no or little impairment.

### Main Points

- Batten grafts are effective in reducing nasal obstruction.
- There was a significant improvement of the Nasal Obstruction Symptom Evaluation score in patients receiving batten grafts.
- No complications were observed after nose surgery with batten grafts.
- By choosing a narrow batten graft, visible fullness of the nose from outside can be avoided.
- Rhinoresistometry did not detect the clinically present alar collapse.

### Rhinoresistometry

For rhinoresistometry (RMM), the RHINOSYS® (Happersberger Otopront GmbH, Hohenstein, Germany) rhinomanometry (RMM) system was used. It has high-quality sensors that deliver precise results, especially at low flow and pressure conditions, that is near zero-crossing. Rhinoresitometry is a computer-assisted further development of RMM, which allows the quantification of alar collapse. Alar collapse occurs in regions with a soft nasal wall due to an acceleration of the respiratory air at nasal stenosis, which results in a local negative pressure according to Bernoulli's law. Alar collapse causes a disproportionate increase in nasal airway resistance at increasing flow rates. In RMM, the nasal volume flow is plotted on the *x*-axis and the corresponding nasal respiratory resistance on the *y*-axis during slightly forced inspiration and expiration. From the values at low flow rates without collapse, the airflow/resistance curve is extrapolated for a hypothetical stable lateral nasal wall. This is compared to the actually measured curve. The divergence of these 2 curves in inspiration directly correlates with the extent of alar collapse. A nasal volume flow of 500 mL/s for both nostrils corresponds to the value at medium physical effort. In order to avoid nose deformation, no nozzles are used, but the pressure tube is adapted to the nostril with an adhesive plaster in an airtight way.

### Alar Collapse

The presence of an alar collapse was examined and recorded by an experienced ear, nose and throat (ENT) specialist. Alar collapse was diagnosed when LLC collapse was visible for the examiner during inspiration.

### Surgical Technique

Surgery was performed under general anesthesia following nasal decongestion. A straight cartilaginous strip measuring the distance from the lateral edge of the piriform aperture to the cranial edge of the septum and with the thickness of a matchstick (Figure 1) was harvested from the middle septal area via a vertical mucosal incision. If septal surgery was performed, the cartilage was harvested at the site of vertical chondrotomy (Figure 2). Other donor sites were the cavum conchae or the cartilaginous part of the ribs.

The lateral nasal wall was approached via an intercartilaginous incision between the ULC and LLC of the nasal vestibule. The caudal margin of the UCC was identified, and a mucosal pocket was prepared directed from the lateral edge of the piriform (A) aperture to the ventrocaudal septal attachment of the UCC (B) (Figure 3). The center of the pocket lies at the point of maximum collapse, as assessed preoperatively. The cartilage graft is positioned under light tension providing some outward bend between ULC and LLC (Figure 4). The size of the pocket is critical. It must be large enough to hold the graft. Because of the exact size of the pocket, a suture fixation is not necessary. However, if it is too large, the graft may dislocate. The vestibular skin incision is then closed with an absorbable suture. The batten graft is hardly visible from outside (Figure 5); however, the patient should be informed that there could be a slight thickening of the lateral nasal wall.

### Data Analysis

For data description, means and SDs were calculated. Nominal and ordinal scaled data were recorded. Normally distributed

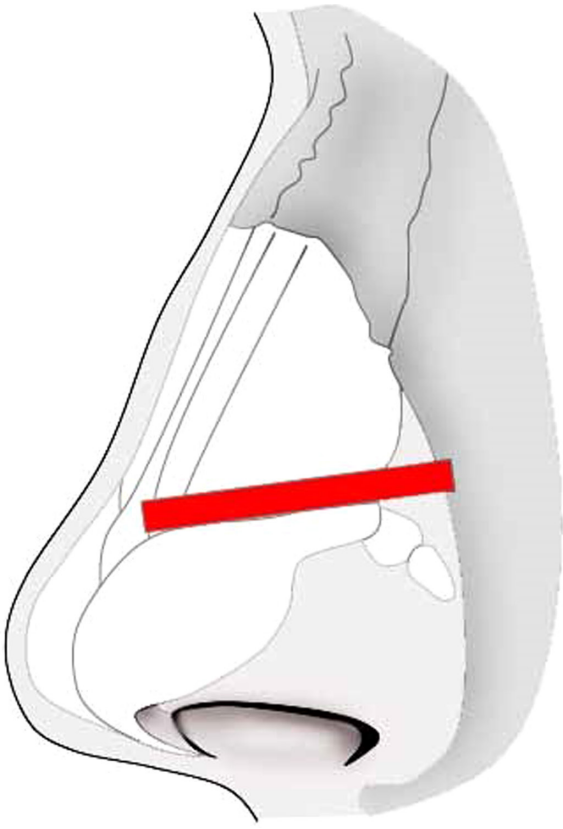


Figure 1. Position and thickness of the batten graft (red).

results were compared with paired *t*-tests; otherwise, Wilcoxon signed-rank test was used. The contingent coefficient based on the chi-square statistic was used for statistical correlations. This is always between 0 and 1, where 0 indicates that there


Figure 2. Cartilage strip taken from nasal septum.

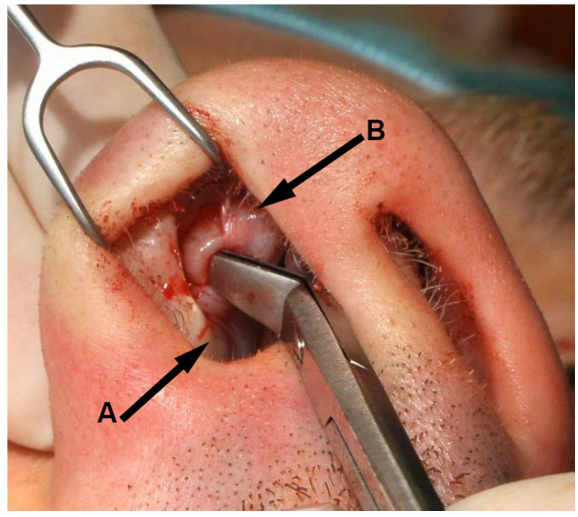



Figure 3. Prepearing the mucosal pocket, (A) lateral edge of piriform aperture, (B) ventrocaudal septal attachment of UCC.

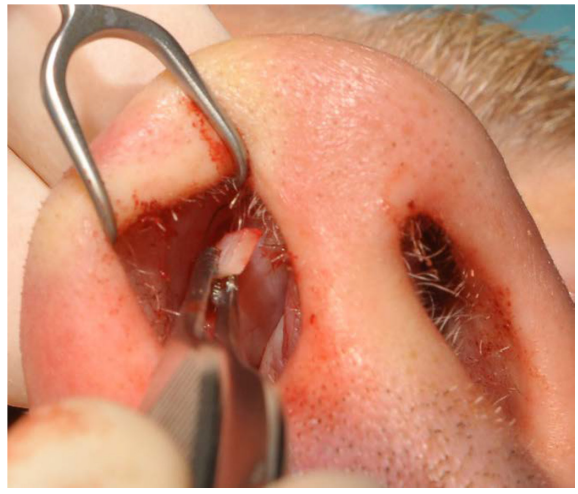


Figure 4. Insertion of the batten graft.

is no correlation between the row and column variables and 1 indicates a strong correlation. The statistical analysis was performed using IBM Statistical Package for the Social Sciences.

## Results

### Population

In 20 patients aged between 29 and 74 years, the mean age was 47 years (±13.5). Out of those 20 patients, 16 were male and 4 were female. All patients were Caucasian. None of the patients had previous surgery or nasal trauma. Two of the 20 patients were diagnosed with allergic rhinitis and treated with a steroid spray. A bilateral batten graft was applied in 16 patients, and 4 patients received a 1-sided batten graft. In 12 patients, the batten graft was prepared using septal cartilage, and in 8 patients using cartilage of the aural concha. A higher improvement of the total NOSE score was observed when the batten graft was made of septal cartilage compared to that when batten grafts were made of auricular cartilage. However, this was not statistically significant ($P = .3$). A conchotomy was additionally performed in 10 patients. An endonasal approach was chosen in 17 cases, and an open technique was used in the remaining 3 cases (Table 1).

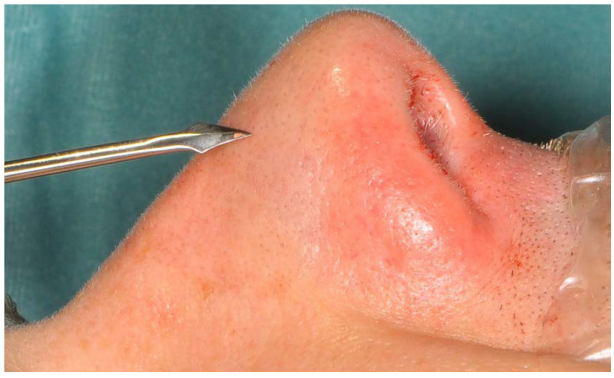


Figure 5. Outside result after application of batten graft.

### Nasal Obstruction Symptom Evaluation Score

Before surgery, the median NOSE score was 15.4, and following surgery, it was 5.4 (Wilcoxon signed-rank test, $P < .001$). Overall, 18 out of 20 patients reported improved nasal breathing (Table 2). Four patients reported that they had no symptoms of nasal obstruction at all after surgery. No patient reported a worsening of symptoms.

### Rhinoresistometry

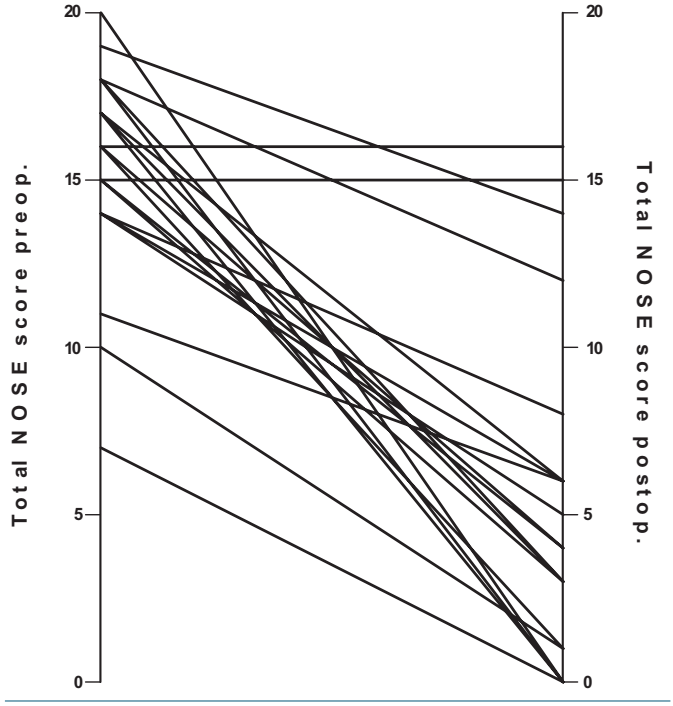
Alar collapse was preoperatively present in 18/20 patients and postoperatively in 4/20 patients. In 4/20 patients, the alar collapse was unilateral, and in 16/20 patients, it was bilateral. The reference for the clinical diagnosis was the examination by an experienced ENT specialist. For evaluation of the potential as an objective diagnostic tool, RRM was applied afterward to confirm or revoke alar collapse. Preoperatively, the investigator's diagnosis (whether alar collapse is present or not present) matched the results of RRM in 5 out of 18 patients. In 13 patients, the RRM did not detect the clinically present alar collapse.

Data were compared by means of the crosstabulation. The contingency coefficient was 0.17. Postoperatively, the results of the RRM measurement and the investigator's diagnosis of alar collapse were concordant in 11 patients. In 9 patients, there was no consistency. The RRM did not recognize the alar collapse in 2 patients, and in 7 patients a false positive result was generated. The contingency coefficient was 0.1.

Table 1. Study Population

| | |
|---|---|
| Gender ($P=.6$) | |
| Male | 16 |
| Female | 4 |
| Surgical access ($P=.8$) | |
| Open | 3 |
| Closed | 17 |
| Batten graft ($P=.6$) | |
| Unilateral | 4 |
| Bilateral | 16 |
| Additional surgical procedure | |
| Septoplasty ($P=.2$) | 16 |
| Conchotomy ($P=.4$) | 10 |
| Harvested cartilage ($P=.3$) | |
| Septal cartilage | 12 |
| Auricular cartilage | 8 |

Table 2. NOSE Score Preoperative and Postoperative




Lines are showing the difference of the NOSE score from preoperative to postoperative in each of the 20 patients.

## Discussion

A common cause of nasal obstruction is the collapse of the lateral nasal wall during forced inspiration. This can be corrected surgically and/or conservatively.[12,13] Spreader grafts are a surgical method to improve the cartilaginous structure in the INV area. Spreader grafts are rectangular strips fixed between the ULC and the septum, thereby widening the nasal valve. Here, we report our experience with nasal batten grafts. Since the initial description, numerous studies have confirmed this surgical treatment option as promising.[9,10,14] However, there are significant differences in the surgical technique, graft material and dimensions, and the exact position. We studied the outcome of nasal batten grafts in 20 patients with alar collapse. A subjective improvement of nasal breathing was reported postoperatively in 18 patients, and 2 patients felt no improvement. No patient reported a worsening of nasal breathing. The NOSE score[11] was calculated pre- and postoperatively. There was a significant improvement in the overall score ($P < .001$). The mean score decreased from preoperative 15.4 to postoperative 5.4 points. However, this subjective improvement was not detectable by nasal functional diagnostics. The result of RRM was not suitable for detecting an alar collapse, both pre- and postoperatively.

Patients with batten grafts harvested from septal cartilage had a lower postoperative NOSE score than patients with grafts from the aural concha; however, this was not statistically

significant. Harvesting a graft from the septum provided a more stable piece of cartilage than from the aural concha. Furthermore, harvesting septal cartilage for a batten graft was advantageous as no additional intervention at another body site with all the associated discomfort was necessary. Moreover, improvement of the NOSE score cannot be attributed to the batten graft alone, as 19 patients underwent further rhinosurgical interventions. In 16 patients, a septoplasty was additionally performed, and in 10 patients a conchotomy was performed. The improvement in nasal obstruction could have been due to these additional rhinosurgical interventions.

The surgical technique performed at the Department of Otorhinolaryngology, Medical University of Innsbruck, has many similarities to surgical techniques described by other authors.[9,10,14] The batten grafts used in Innsbruck are exclusively made of autologous cartilage, primarily of the septum, secondary from the ear cartilage, and only in few patients from the cartilaginous part of the rib. Other authors used foreign material in prefabricated shapes.[15] In addition, the piece of cartilage used in our study was not pre-bent, longer, and narrower compared to graft techniques reported by other authors. It was crucial to create a precise intercartilaginous pocket, where the batten graft can stay between the ULC and LLC. Because of the precise pocket, no suture fixation was necessary. The batten graft extended from the piriform aperture to the cranial edge of the septum. Because of the position, we did not observe any bending of the batten graft. In a too large pocket or very small batten grafts not covering the whole area from the piriform aperture to the cranial edge of the septum, a translocation causing a non-sufficient effect of the batten graft might be possible. The graft described by Toriumi was curved, and the convex surface of the cartilage was oriented laterally. Mostly, the alar batten grafts were applied caudally to the existing lateral crura and extended only from the lateral third of the lateral crura to the piriform aperture. Some authors reported that patients were not satisfied with the surgical result because of the visible outer delineation of the graft. This could be related to the larger size of the graft.

André et al[16] proved the long-term stability of the lateral nasal wall by using batten grafts. The graft should be sufficiently large, long, and well positioned. By choosing a graft that is too large, the batten graft can become very stable but also visible from the outside. In order to achieve the highest possible stability, this aspect has been taken into account in our study, and the batten graft was positioned at the level of the caudal edge of the ULC. The used graft is supported by the piriform aperture and the septum edge. The aim of our narrow batten graft was to achieve a stiffening in the region of the inner nasal valve and at the same time to avoid a visible fullness in this area.

The batten graft was used in this study to prevent alar collapse; in patients with severe INV stenosis, the batten graft can also be combined with other surgical techniques such as the spreader graft, autospreader graft, butterfly graft, Mitek bone anchor suspension, or a titanium butterfly implant. There exist also a variety of suture techniques such as the flaring suture suspension, lateral pull-up suspension, and piriform rim suture suspension to treat nasal valve collapse.[17]

A conservative management of INV stenosis as internal nasal dilatators is a suitable alternative to the surgical techniques, especially in patients with elevated risk for anesthesia.[18]

Limitations of this study are the small number of patients and also the combination of batten graft with other surgical techniques such as septumplasty and conchotomy.

## Conclusion

Batten grafts are a simple and a very effective method to cure nasal obstruction caused by a weakness of the lateral nasal wall.

**Ethics Committee Approval:** Ethical committee approval was received from the Ethics Committee of the Medical University Innsbruck, Austria (Approval No: 313/4.8).

**Informed Consent:** Written informed consent was obtained from all participants who participated in this study.

**Peer-review:** Externally peer-reviewed.

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**Declaration of Interests:** The authors have no conflict of interest to declare.

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