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Methods of pyriform aperture lateralization: a systematic review

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ABSTRACT
Chronic nasal obstruction is an important problem of modern otorhinolaryngology, as it significantly reduces the quality of life and often requires surgical treatment. Standard treatment approaches for nasal obstruction, such as septoplasty and inferior turbinate surgery, are often ineffective. Failed surgery of nasal septum and inferior turbinates can be explained by internal nasal valve whose dysfunction leads to nasal obstruction. In some cases, narrowness of pyriform aperture can lead to nasal valve dysfunction and consequent nasal obstruction. Several reports devoted to various techniques of pyriform aperture enlargement through simple resection of the edge of pyriform ridge have been published since 1952. This review is devoted to osteoplastic methods of pyriform aperture enlargement. In these cases, surgeon keeps the bone edge of pyriform ridge intact, resects more lateral and deeper bone fragments and partially displaces lateral wall of the nasal cavity in lateral direction. Despite technical complexity compared to simple resection, these lateralization techniques have a wide scope of application in nasal cavity. They are effective for symptoms of nasal obstruction.

Keywords: *pyriform aperture, internal nasal valve dysfunction, lateralization of pyriform aperture, airway repair.*

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Chronic nasal obstruction is an important problem of modern otorhinolaryngology. Impaired nasal breathing is not only one of the most common symptoms in rhinology, but also a source of significant discomfort and financial costs for the patient [1, 2]. Chronic nasal obstruction inevitably impairs working capacity, results persistent sleep disturbances, irritability, malaise and decreased appetite. These aspects significantly reduce the quality of life and often require surgical treatment [3].

As nasal obstruction is one of the most common symptoms in rhinology, septoplasty with correction of inferior turbinates is one of the most frequent surgical procedures performed by ENT surgeons for correction of nasal obstruction [4, 5]. Although septoplasty with surgery of inferior turbinates for nasal septum deformity and concomitant chronic rhinitis is the "gold standard" in the treatment of nasal obstruction, its effectiveness can vary significantly (from 43% to 85%) and paradoxically put questioned by some authors [6–9]. This inspired the studies comparing septoplasty with non-surgical treatment of nasal septum deformity and nasal obstruction. These trials paradoxically question the benefits of surgical techniques [10]. In addition, prevalence of nasal septal deformity reaches 80% according to the literature, and only minority of these patients suffer from nasal obstruction and require surgical treatment [11]. At the same time, objective measurements do not always correlate with subjective indicators of effective septoplasty [12].

We can explain unsuccessful surgery of nasal septum and inferior turbinates by internal nasal valve whose dysfunction leads to nasal obstruction. Nasal valve is primary regulator of the volume of air passing through the nasal cavity [13]. According to C.J. Woodhead (1995), location and shape of the nasal valve are variable. Considering pressure in various parts of nasal cavity, we can conclude that the level of anterior end of inferior turbinates is a segment limiting the flow of inhaled air. However, the narrowest point displaces towards pyriform aperture after anemization when anterior end of inferior turbinates contracts (or as a result of previous surgery). Thus, narrowness of pyriform aperture can also lead to nasal obstruction in this case [14].

There are few reports devoted to the problem of enlargement of pyriform aperture for nasal obstruction. Plastic surgeon Douglas B. (1952) reported the first data on this issue. He described pyriform aperture enlargement via simple resection of the edge of pyriform crest at different levels [14–24]. Resection is performed via endonasal or sublabial access, and surgeries are often combined with other procedures for correction of nasal obstruction. This fact complicates assessment of surgical effectiveness. A review of available studies devoted to surgical enlargement of pyriform aperture via resection of pyriform crest is presented in the **Table** (MEDLINE, Medscape and PubMed databases, semantic searching in ResearchGate).

The presented methods of pyriform aperture surgery aimed at enlargement of its boundaries and correction of nasal obstruction are simple methods with resection of piriform crest. To date, there are also more complex methods for nasal cavity enlargement including expansion

Reports devoted to surgical enlargement of pyriform aperture via resection of the pyriform crest

Author and access	Number of patients	Indications	Surgical features	Result
B. Douglas (1946) [16], endonasal	7	Nasal obstruction; rhinoscopy data; ineffective correction of nasal septum and turbinates	S-shaped incision with displacement of the flaps; stenting for 7 days	Improvement
L. Rozner (1964) [17], endonasal	1	Nasal obstruction; rhinoscopy data; ineffective correction of nasal septum and turbinates	Curved incision; resection of a bone fragment 10×5 mm; anterior tamponade for 2 days	Improvement
R. Shetty (1977) [18], endonasal	30	Nasal obstruction; rhinoscopy data; ineffective correction of nasal septum and turbinates	Curved incision; resection of the fragment over 10 mm	28 — improvement, 2 — no effect
C.J. Woodhead (1995) [14], endonasal	—	Nasal obstruction; rhinoscopy data; positive Cottle test; ineffective correction of nasal septum and turbinates	Z-repair	—
T. Erdem et al. (2004) [19], intraoral	2	Nasal obstruction; CT and rhinoendoscopy data; no deviation of nasal septum; narrowed angle of internal nasal valve	Anterior tamponade for 5 days; combination with open rhinoplasty (spreader grafts)	Improvement
W. Smith et al. (2009) [20], endonasal	40	Nasal obstruction; no deviation of nasal septum; no hypertrophy of inferior turbinates; collapsed ala of nose	—	Improvement
J.E. Gilde et al. (2015) [21], endonasal	6	Nasal obstruction (NOSE scale); rhinoscopy data	Z-repair; resection of a bone fragment 10 x 5 x 8 mm; 5 out of 6 cases – combination with rhinoseptoplasty and surgery of turbinates	Improvement
S. Roy et al. (2015) [22], endonasal	26	Nasal obstruction (VAS); significant narrowing of pyriform aperture according to rhinoendoscopy data; ineffective previous septoplasty and correction of inferior turbinates or internal nasal valve repair	Curved incision; piezo instrument; resection of a bone fragment 2 mm wide + resection of the head of inferior turbinate; combination with rhinoseptoplasty and surgery of inferior turbinates in 24 out of 26 cases	23 — improvement, 3 — no effect
O. Sofia et al. (2017) [23], intraoral	8	Nasal obstruction (NOSE scale); anterior active rhinomanometry; positive Cottle test	—	7 — improvement, 1 — no effect
K.B.Lipsky et al. (2021) [24], endonasal	20	Nasal obstruction (NOSE scale); CT data without measurement	Piezo instrument; resection of a bone fragment of the pyriform crest + resection of the head of inferior turbinate	—

Note: CT - computed tomography; NOSE scale - Nasal Obstruction Symptom Evaluation; VAS - visual analogue scale.

at the level of pyriform aperture. These surgical methods including pyriform aperture lateralization can be attributed to osteoplastic procedures. Indeed, bone edge of pyriform aperture is not resected and remains intact, but shifted in lateral direction due to resection of other lateral bone fragments. Alternatively, bone edge of pyriform aperture is resected along with deep fragments of maxilla and lacrimal bone. Thus, pyriform aperture enlargement is accompanied by expanding the area of nasal valve that potentially improves respiratory function.

The purpose of this study was a systematic review of methods for pyriform aperture lateralization.

Searching for literature data was carried out in the Medscape and PubMed databases using the following keywords: pyriform aperture or foramen, lateralization or repair of pyriform aperture, stenosis or narrowness of pyriform aperture, relief of nasal obstruction.

The review includes studies on surgical treatment of adults (over 18 years old). We excluded the reports containing simple resection for pyriform aperture enlargement.

The first report devoted to this issue was published by Triaca A. et al. (2012). The author presented a new technique for nasal valve enlargement via lateralization of nasal walls. Surgery was performed under local anesthesia and consisted of resection of a semilunar bone fragment 0.3–0.5 mm wide using a thin drill or piezoelectric saw. Height of this fragment was from the bottom of pyriform aperture to the level of inferior turbinate parallel to the edge (and lateral to it by 0.5 cm) of the lower third of the pyriform aperture. After removing superficial bone layers, further deeper resection should be performed without damage to mucous membrane of nasal cavity and maxillary sinus to avoid unnecessary scarring. At the next stage, lateral wall of anterior parts of nasal cavity is broken like a “green branch”, displaced from the side of the nostril in lateral direction and fixed by a small plate and two screws in a new position. This procedure is performed via intraoral access and 1.5-cm incision (including bilateral surgery if necessary). The authors described 15 patients who subjectively noted a significant improvement in nasal breathing without major complications. However, objective data in long-term follow-up period were not presented. In authors’ opinion, the main advantages of this technique are local anesthesia, technical simplicity and patient satisfaction since it does not entail aesthetic changes or

the use of complex time-consuming methods for correcting the dynamic component of internal nasal valve. Stable cross-sectional enlargement of the nasal valve significantly improves nasal breathing [25].

Simmen D.B. et al. (2015) and Sommer F. et al. (2016) consistently and jointly described a similar technique in their modification. In contrast to Triaca A. et al., these authors used endonasal approach and called their operation pyriform turbinoplasty. This procedure can be combined with lateralization of lateral wall of nasal cavity for the best effect on nasal obstruction [26, 27]. The essence of pyriform turbinoplasty is submucosal reduction of a fragment of the frontal process of the maxilla and lacrimal bone using a 3-mm osteotome. This procedure enlarges nasal valve with minimal damage to nasal mucosa [26]. If necessary, surgery can be supplemented by lateralization of lateral wall of nasal cavity via continuous dissection in posterior direction (following medial wall of maxillary sinus until posterior attachment of inferior turbinate to the palatine bone), resection of the base of inferior turbinate, appropriate part of pyriform aperture and lacrimal bone behind the lacrimal canal [27].

The results based on a computer simulation model (ANSYS Fluent solver, ANSYS Workbench 14) demonstrate higher airflow through the nasal cavity without significant changes in normal air distribution after surgical treatment [26, 27]. Thus, pyriform turbinoplasty and lateral nasal wall lateralization are submucosal surgical procedures expanding the area of nasal valve without any mucosal resection. Computational aerodynamics proves that these procedures lead to normal uniform airflow distribution. This ensures uniform heating and humidification of the inhaled air without significant changes in architectonics of nasal cavity. Despite the optimistic conclusions, the authors indicated only one patient who underwent this surgery with positive results. However, this outcome was not confirmed by objective methods.

Wong B.L.K. et al. (2018) described their combined concept of surgical treatment of nasal obstruction (airway plasty). This approach included septoplasty, turbinate surgery and pyriform turbinoplasty with lateral nasal wall lateralization similar to modification by D.B. Simmen et al. (2015) and F. Sommer et al. (2016). Twenty-eight patients underwent surgery, and 23 ones were followed-up throughout a year (5 patients were lost). The SNOT-22 questionnaire and 10-point visual analogue scale for nasal obstruction were used to assess the effectiveness of surgical treatment. The authors selected the patients with ineffective 6-month drug therapy and structural nasal obstruction. The authors reported positive results. SNOT-22 score significantly decreased from 51.7±10.3 before surgery to 23.3±8.3 after 12 months (by 54%, $p<0.00006$). VAS score of nasal obstruction significantly decreased from 9.0±0.6 to 2.2±0.9 (by 76%, $p<0.00005$). In all cases, combined surgery included lateral nasal wall lateralization, septoplasty and turbinate surgery. Therefore, it is impossible to evaluate the result of each intervention, but their combination (airway plasty) provides significant positive effect [28].

Thus, lateral nasal wall lateralization is a rather young surgical technique first described by Triaca A. et al. in 2012 [25]. Despite positive results of various surgical modifications (39 cases) and no significant side effects, these procedures have not yet become widespread. In our opinion, the main cause is difficult surgical technique, especially in comparison with resection methods for pyriform aperture enlargement. However, the possibilities of treating chronic nasal obstruction are greatly expanded in case of correct technique lateral nasal wall lateralization.

Further research is needed to determine functional and anatomical indications for the above-mentioned surgical procedures.

No conflict of interests to declare.

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