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The nasal pyriform aperture and its importance

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Introduction

Knowledge of the nasal pyriform aperture's anatomy and contribution to nasal airway resistance is important, to any surgeon operating in the area of the nasal pyriform aperture.

This article aims to give a systematic overview of the nasal pyriform aperture, its anatomy, embryology, ethnological variations, diagnostic tools, investigations, surgical options and objective outcome measures.

Anatomical definition

The nasal pyriform aperture is the bony anterior limitation of the nasal skeleton. The maxillary bone forms the inferior and lateral boarders and the nasal bone, forms the superior boarder, of this pear shaped aperture. The medial boarder is formed by the rounded edge from the premaxilla bone and the sharper edge of the maxilla. These two bones fuse anteriorly, to form the anterior nasal spine. The limen nasi is a landmark for the location of the pyriform aperture.

Embryology of the pyriform aperture

Warbrick described 4 stages of embryologic development of the nose, thought to be complete by the 8th week of gestation. The first stage is the formation of the nasal placodes. During the second stage the nasal groves arises from the nasal placodes. In the third stage the nasal groves transforms in to the nasal pits and at the fourth stage sees the deepening of the nasal pits and the formation of the primitive posterior nares. The anterior nares are formed from fusion of the maxillary process with the lateral and medial nasal process. From the 8th till the 24th week of gestation, the nostril is filled by an epithelial plug. It is the failure of this plug to reabsorb which results in stenosis of the anterior nares [1].

Failure to the embryological process, resulting in congenital stenosis of the pyriform aperture presents with airway distress in the newborn. Congenital stenosis of the pyriform aperture was first described by Brown in 1989 [2]; it can result in variety of symptoms from unilateral nasal blockage, failure to thrive or life threatening airway distress. The presentation is similar to that of Choanal atresia, and stenosis of the pyriform aperture should be kept in mind, when assessing a newborn with airway distress. Stenosis of the pyriform aperture is associated with a single upper incisor in about 50% of cases.

Relation to the nasal valve

Mink first described the nasal valve in 1903. The nasal valve is the narrowest point in the nasal cavity and has the highest airflow resistance. It is divided into an external and internal nasal valve [3].

The exact location of the nasal valve has been debated. The external nasal valve is formed by the columella, the nasal floor, and the nasal rim. The fibrofatty alar and lower lateral cartilage tissues make up the lateral and anterior borders along with the caudal septum and pyriform aperture. The nasalis muscle dilates this portion during inspiration. The internal nasal valve area borders are the septum, pyriform aperture floor, and head of the inferior turbinate and the caudal border of the upper lateral cartilage.

The pyriform aperture region of the nasal valve has been found to have the smallest cross sectional area of the whole nasal valve [4] and 2/3th of the total nasal resistance is in the bony cavum with maximum at the level of the pyriform aperture [5].

The maximal level of nasal airflow resistance, using rhino manometry, was found at the region of the pyriform aperture and the aperture should be regarded as the flow limiting segment in the nose [6]. In view of the pyriform aperture influence on airflow, it is important to recognize the importance of the pyriform aperture when assessing patients for functional nasal surgery. A narrowed pyriform aperture could limit the success of septoplasty and reduction of inferior turbinates. Widening of the pyriform aperture may be warranted in selected cases or in patients with previous failed septoplasty and/or turbinate surgery [7]. A review of surgical techniques for treatment of nasal valve collapse, reviewed 26 papers on surgery to the internal nasal valve, none of which included surgery to the bony part of the pyriform aperture [8].

Racial and gender differences in the nasal anatomy

Various ecogeographical variations in the nasal passage have been described. Caucasians have greater nasal cavity height and lengths and smaller breadths than African Americans (Franciscus 1995). In the decongested nose the Caucasian nose shows a much higher surface-area-to-volume-ratio than the decongested African American nose [9]. Looking at differences between Caucasians, Chinese and Indians, Abdelkader et al showed no significant difference in the lengths and width of the columella, but the pyriform aperture was longer in the Indian group, and the maximum with of the aperture was narrowest in the Chinese group [10]. Afro Americans have been found to have a more oval shaped pyriform aperture, resulting in larger pyriform openings [11]. Knowledge of these measurements is important in cosmetic reconstruction of the nose, but may also be predictors of outcome of septal, turbinate and pyriform aperture surgical procedures.

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The total width of the nasal aperture was assessed in 80 men and women, using healthy individuals measurement, obtained by CT scans. The mean width was suggested to be 21.9 +/- 2.1 mm in men and 21.0 +/- 2.2mm in women [12]. The paper was published by Turkish authors without mention of the ethnicity of the included patients. Hommerich suggested these measures to be 23.6 mm for men and 22.6 mm for women after assessing 116 Caucasian patients, using 3-D reconstructed CT scans, with no suggestion of standard deviation [13]. Lee looked at 75 Korean patients and suggested an average pyriform aperture with of 24.34 +/- 2.33 mm for men and 22.82 +/- 2.04 for women [14].

Hoffman's cadaveric measurements suggest an average 26.7 mm pyriform aperture width in Africans [15].

These measurements are summarised in Table 1.

Author	Male (mm)	Female (mm)	Ethnicity
Erdem	21.9 +/- 2.1	21.0 +/- 2.2	Unknown
Hommerich	23.6	22.6	Caucasian
Lee	24.3 +/- 2.3	22.8 +/- 2.0	Korean
Hoffman	26.7		African

Assessing the anatomy of the pyriform aperture

In congenital pyriform aperture stenosis the use of 3D CT has been advocated [16,17]. This allows for 3-dimensional measurements to be used. Nasal pyriform aperture height, mid interval distance, interprocess distance at the lower fourth of the aperture and narrowest interprocess distance are the four main measures used to determine the diagnosis. All these are measured in the coronal plane.

In adults 3-D CT scanning is also the investigation of choice. Main measure suggested is the maximum interaperture distance in the coronal plane. No exact normal minimum aperture width is suggested in the literature. Only very few normal controls, forming the basis for the normal values discussed above, were found to have a width of less than 19 mm. No normal controls have been found to have an aperture width of less than 18 mm [13]. Minimum normal measures may not be useful in unilateral pyriform aperture stenosis.

Woodhead suggests an axial assessment of the projection of the pyriform aperture, with no suggestion of scale or size guidance. Forensic specialists have studied the dimensions of the nose comparing the actual nasal width, with underlying bony structures, in an attempt to set guidelines used in facial reconstruction on skulls in criminal and anthropological cases.

Being able to measure the size of the aperture in clinic could help clinicians decide on the best surgical treatment for nasal blockage. To do this you need to take in to consideration the nares and the dermo-fibro-cartilaginous element of the total nasal width. The recommended normal measures are calculated by using the external intra alar width, and deduction 12.2 mm in Caucations and 16.8 mm in Africans. This method was developed by measuring cadaveric specimens [15]. This formula could potentially be used in the clinical setting by measuring the interalar width to calculate an estimated pyriform aperture width.

Cosmetic importance

A case report describes the use of pyriform aperture augmentation, rather than reduction, as a rejuvenating process, but no considerations of functional outcomes were described [18].

It is thought that low lateral osteotomies used in some rhinoplasty approaches may cause an iatrogenic narrowing of the aperture and this should be considered prior to rhinoplasty. The bone is not removed, but in-fractured, which may reduce the nasal airway. A cadaveric study of nasal airflow, using acoustic rhinometry following low lateral osteotomies, failed to show a reduction in airflow, compared to high lateral osteotomies, so the contribution of low in-fractures to nasal airflow compromise has not been proved [19].

Surgical approach

Various techniques have been used to surgically widen the nasal process of the maxilla. Incision via the Caldwell Luc or sublabial-buccal incision has been used by numerous authors [12,18]. An incision in the floor of the nose has been described by Adamson [20]. Scar tissue and part of the pyriform aperture was removed using an incision in the sagittal plan, addressing vestibular stenosis. Woodhead described and intranasal z-plasty in the area of the pyriform aperture [21]. Burnstein described a transnasal approach in conjunction with septorhinoplasty, but no details of the exact site of incision were found in this article [22]. Smith et al describes an incision just lateral, anterior and superior to the inferior turbinate in the area of the nasal process of the maxilla [8]. Once the nasal process has been laid free of soft tissue and periostium, various methods have been described for resection of the bone, including bone rongeur, drilling, chisel and mallet.

Outcome measures and Safety of surgery including nasolacrimal duct considerations

Main consideration when undertaking pyriform aperture surgery is damage to surrounding structures. It is particularly important to consider the location of the lacrimal duct. The distance from the limen nasi, to the lacrimal duct, is 20.8 mm [23]. No reported adverse events were found on review of surgical procedures to the nasal pyriform aperture. In particular no damage to the lacrimal duct or sack has been reported in the literature.

Smith et al looked at post operative outcomes in 40 patients having had intranasal resection of the pyriform aperture, a few reported mild post-operatives bruising.

In adults the problem arises in measuring post surgical outcomes as most patients will only have a preoperative CT scan and no comparable studies exist of pre and post operative nasal aperture width. No quality of life studies or nasal airflow studies has been undertaken in patients who have undergone nasal aperture surgery.

Conclusion

The nasal process of the maxilla is part of the narrowest part of the nasal valve. Congenital and acquired forms of stenosis of the pyriform aperture have been described, best diagnosed by the use of 3D CT scans. A pyriform aperture of less than 18 mm can be considered narrowed, though these measurements may not be useful in assessment of unilateral stenosis. Various approaches and resection techniques have been described, but no qualitative outcome studies has been undertaken so far. Nasal aperture surgery involving the nasal process of the maxilla may be an underestimated valuable adjuvant surgical option, available to treat patients with resistant nasal valve narrowing.

Further studies to determine functional and anatomical outcomes, are needed. Procedures to widen the nasal pyriform aperture, has so far been shown to be safe with no reported long term adverse outcomes.

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