Comparative study of turbinate reduction using four types of lasers

Thesis

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INTRODUCTION

Anatomically, the inferior turbinate is a separate bone of the lateral nasal wall that is attached to the lacrimal, maxillary, ethmoid and palatine bones, covered by erectile vascular tissue which is covered by ciliated pseudo stratified epithelium. Physiologically, nasal turbinate help in moistening, worming, filtration, and regulation of the inspired air. Because its capacity to increase and decrease its volume, controlled by the autonomic nervous system. The turbinate contributes to the nasal cycle also. Irreversible turbinate hypertrophy may be due to allergic rhinitis, vasomotor rhinitis or other causes. Medical treatment should be firstly attempted aiming at improving the underlying disease and it is normally based on anti-histamines, anticholinergics, nasal decongestants, and sod.chromoglycate, topical corticoids or other drugs. Prophylaxis against allergens and irritant must be taken into consideration. Surgical treatment of nasal turbinate has been indicated when medical treatment fails. Many forms of procedures have been described to reduce the volume of inferior turbinate such are:

a) Procedures involving the injection of intraturbinal substance as sclerosing materials
b) Mechanical procedures: concha fracture or subluxation.
c) Procedure that reduce the parenchyma: electro cauterization, cryosurgery.
d) Resection procedure: Partial resection, total resection, sub mucous resection

Laser surgery can be classified as a procedure that causes reduction of the parenchyma.

Laser surgery of inferior turbinate was first described in **1977 by Lenz et al.**. In **1982 Mittelman** reported the first results of laser turbinate reduction. The most commonly used lasers in the nasal cavity are: CO2, KTP, Diode, Ho: YAG, Argon and Nd: YAG laser. They vary in wavelength and in turn, in their tissue reaction and absorption.

The aim of this present work is to prove clinically the efficacy of laser-assisted turbinate reduction (LATR) and to compare between four different types of lasers with different techniques in this respect.

REVIEW OF LITERATURE

Anatomy of the Inferior Turbinate

Embryology

A Series of elevations appear on the Lateral nasal wall from the sixth fetal week which ultimately form the turbinates. The most inferior or maxilloturbinal forms the inferior turbinate. The middle, superior and supreme turbinates result from reduction of the complex ethmoturbinal system found in Lower mammals. Similarly the primitive nasoturbinal is represented by the agger nasi region and uncinate process of the ethmoid **(Scott-Brown's Otolaryngology, 1997).**

Inferior turbinate develops by endochondral ossification of components of the mesethmoid and ectethmoid. The chondral framework of the inferior turbinate consists of a double lamella and two separate ossification centers that develop between the fifth and seventh month of fetal life. The separate ossification centers meet by the eighth fetal month. During ossification, the inferior turbinate detaches from the ectethmoid and becomes an independent bony structure **(Cankaya H et al. 2001)**.

Descriptive Anatomy

The Lateral wall of the nasal cavity has three Conchae or turbinates named the superior, middle and inferior turbinate according to their relative location. The superior and middle turbinate are part of ethmoid bone while the inferior turbinate is a separate bone. It extends from the body of the maxilla to the ethmoid crest on the perpendicular plate of the palatine bone. The bone has a maxillary process which articulates with the inferior margin of maxillary hiatus. It also articulates with, ethmoid, palatine and lacrimal bones, completing the medial wall of the nasolacrimal duct **(Gary F et al.1985).**

It has irregular surface; perforated and grooved by vascular channels to which mucoperiostium is firmly attached **(Scott-Brown's Otolaryngology, 1997).**

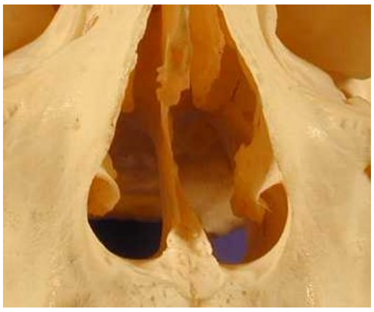

Figure (1)

Inferior turbinate bone and bones of nasal cavity

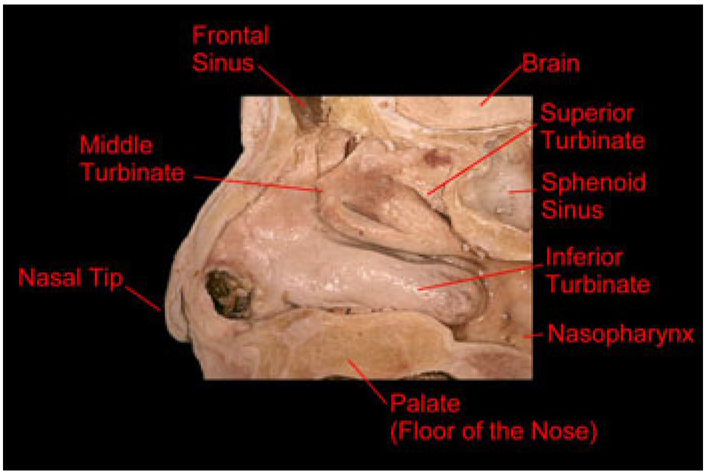

Figure (2)
Lateral wall of the nasal cavity

Inferior meatus

It is that part of the Lateral nasal wall Lateral to the inferior turbinate. It is the largest meatus, extending almost the entire length of the nasal cavity. The meatus is highest at the junction of the anterior and middle third. In adults this ranges from 1.6 to 2.3 cm (mean 1.9 cm). The nasolacrimal duct opens into the inferior meatus usually just anterior to the highest point at 1.6 cm from the anterior end of the inferior turbinate. There is no true valve .The opening being covered by small folds of mucosa .It can be Identified in life by gentle massage of the Lacrimal sac at the medial canthus **(Scott-Brown's Otolaryngology, 1997).**

Blood supply

The external and internal carotid arteries supply the lateral wall. The sphenopalatine artery (from maxillary artery and thus external carotid artery) contributes the majority of the supply to the turbinates and meatus. It enters via the sphenopalatine foramen, which lies just inferior and posterior to the horizontal attachment of the middle turbinate. On the turbinates, the vessels are partially embedded in deep grooves. In the inferior meatus the sphenopalatine branch dips below the level of the palate to re- emerge anteriorly and leaving the central portion of the meatus relatively avascular. An area anteriorly is supplied by a branch from the facial and part of the lateral wall adjacent to the palate receives blood from greater palatine artery. The internal carotid artery, via the ethmoidal arteries, supplies the superior lateral wall. There is considerable overlap between the internal and external carotid systems on each side and between right and left sides.

Venous drainage

It is through the sphenopalatine veins via facial and ophthalmic vessels, intracranial via the ethmoidal veins to the dura and to the superior sagital sinus via the foramen cecum **(Scott-Brown's Otolaryngology, 1997).**

Lymphatic drainage

Lateral wall drains with the external nose to the submandibular nodes anteriorly and to the lateral pharyngeal, retro pharyngeal and upper deep cervical nodes posteriorly **(Scott-Brown's Otolaryngology, 1997).**

Nerve supply

Sensory innervation to the turbinate is derived from the anterior palatine nerve from the sphenopalatine ganglion and the lateral nasal nerve, a branch of the ethmoid nerve. The autonomic enervation is divided into parasympathetic fibers originate in the superior salivatory nucleus and sympathetic fibers originate in the inter medio lateral gray column of the upper five thoracic levels. Both fibers joins in the greater superficial petrosal- nerve, pass through the ptyrgoid canal as the vidian nerve, eventually21 passing through the sphenopalatine ganglion before reaching their destination in the lateral nasal wall **(Gary F et al.1985).**

Histology of the Inferior Turbinate

The inferior turbinate is a cigar -shaped structure attached by a narrow shelf like projection to the lateral nasal wall **(King and Mabry, 1993).**

It is composed of three layers: medial and lateral mucosal layers and a central osseous one in between. The mucosal layers resemble each other, except the medial layer is relatively thicker than the lateral one (mean 1.76 Vs. 1.03 mm, respectively). The inferior turbinate, like other respiratory regions, is covered with a pseudostratified ciliated columnar epithelium and also non-ciliated cells, and 10% goblet cell **(Tos, 1976 and Gilead Berger et al.,2000; 2006).**

The epithelium of the anterior tip and inferior border is replaced by low simple cuboidal cells as result of direct and continuous exposure of such areas to the inspired air current **(Proetz, 1939)** .

A thin layer of basement membrane separates the epithelium from the lamina propria, which extends to the periostium of the central bony layer. The medial side of lamina propria is thicker than the lateral one. This difference explains the disparity between the widths of the two mucosal layers. It is build of connective tissue and few lymphocytes and other immuncompetent cells scattered in the subepithelial region. Many seromucus gland inhabit the outer one third of the lamina propria, opening their excretory ducts into the epithelium. It also contains

connective tissue fibers and blood vessels **(Gilead Berger et al.,2000 and 2003).**
These blood vessels form a network of thin walled venous sinusoids (under autonomic control) occupy its deep portion, as well as few large arteries that lie adjacent to the bone **(Gilead Berger et al., 2000; 2003).**
The central osseous layer is a spongy bone made of bony trabeculae separated by spaces contains fatty tissue and blood vessels (in adult life). The trabeculae are thin and composed of irregular bony lamellae with lacunae containing osteocytes. This characteristic shape structure of the bony core of the turbinate (scroll – shaped bone that is eggshell thin and rough in texture) makes it easily cut and shaped by the use of scissors. Also, the overlying soft tissue is firmly adherent to the bone, extending into irregularities and pockets, and so it is difficult to dissect free surgically. The thickness of this bony layer is about 1.03 ± 0.54 mm. So the total width of the whole three layers is about 3.82 ± 0.48 mm and the height is around 7.75 ± 0.91 mm **(Gilead Berger et al., 2000; 2003).**

Cytology of Mucus Membrane

Ciliated cells:
They represent 10–80% of the superficial cells. They are elongated, columnar cells with very chromophilic nuclei. They are surrounded by a covering of very fine cilia 5 – 7 um in length and 0.2 um in diameter with average of 200 cilia per cell **(Hilding, 1965).**

Goblet cells:
They interrupt the ciliated cells by a varying number. On average, there is one goblet cell to four or five ciliated cells. The proportion is greater at the level of anterior zones that are exposed to the streams of inspired air. Their number increases greatly where inflammation ensues. **(Hilding 1965 and Mills, 1990).**

Brush cells:
They are similar to the brush of intestine. They are rarely found in the nasal mucosa **(Rhodin, 1966).**

Basal cells:
They are small cells with darkly stained nuclei present between the other types of cells and lying on the basement membrane **(Mygind, 1979).**

Undifferentiated cells
This cell is a goblet cell then become an undifferentiated cell after mucous secretion **(Stockinger, 1964**).

However **(Ohashi and Nakai, 1983)** encountered these cells only under pathological conditions and were able to differentiate them into either goblet cells or ciliated cells.

Basement membrane

It is a thin structure separating the cells from the adjacent stroma. It consists of amorphous substance and contains very fine reticular and collagenous fibers that are continuous with those of the submucosal. It appears to be riddled with small holes named the basement ducts. **(Mills, 1990).**

On electron microscopy it appears to have a zone of low electron density adjacent to the cell membrane (Lamina Lucida or Lamina Vara) and a zone of higher density adjacent to the stroma (Lamina Densa), both of 40–60 nm thickness **(Cauns, 1970 and Bosman, 1985).**

Lamina propria

It is a layer of connective tissues underlying the epithelium continuing down to the periostium traversed by dens vascular network, nerve fibers, glands, cells which are wade red in the ground substance and blood vessels. It has three layers. The subepithelial zone or lymphoid layer, which contains many cells (Lymphocytes, fibrocytes and histocytes). The histocytes contains very active substance of hydrolytic action and lysozymes. The middle or glandular layer containing seromucus and serous glands .The third is the deep vascular layer which is dense, compact zone and its vessels make up the erectile tissue **(Mills, 1990).**

Normal ciliary Morphology:

The cilium can be defined as extension of the cell as a longitudinal shaft, surrounded by a continuation of the cell membrane, called ciliary membrane. The width of the cilium is 0.2 um while the length is about 6 um. The core of the cilium or "axonerme" is composed of longitudinal micro- tubules in constant number and arrangement, nine microtubular doublets in a ring around two central micro tubules, the "9+2" arrangement **(Afzelius, 1979)**.

The 2 central microtubules are surrounded by semicircular rib like structures, the "central sheath", which is connected to the outer doublets by slender radial threads called the "radial spokes" originating from the microtubules. The central pair of microtubules terminates in a plate, the "basal plate"; just before the shaft of the cilium joins the main body of the cell **(Herzon, 1981)**.

Cilia are extracellular parts of the cells, but they are continuous with an intracellular structure, the "basal body" or kinetosome, by which they are anchored to the cell. The nine peripheral doublets are continuous with

two of the three tubules in the nine triplets of the basal body **(Friedmann and Bird, 1971)**.
The pattern at the tip of the cilium consists of 9+2 singlets where as that at the middle portion of the cilium consists of nine peripheral doublets and two central singlets. In the transitional region of the cilia there are no central fibrils, only nine peripheral doublets. In the region of the basal bodies the nine peripheral doublets become triplets **(Takasaka et al., 1980).**

Microvilli:
Microvilli and cilia occur in close association on the respiratory tract mucosa. Large number of microvilli forming dense, perhaps protective groups around them surrounding the cilia. They are straight fingers like projection of fairly regular height and diameter resembling the feature of the brush border of the intestinal epithelium. The microvillus has a central core, a bundle of fine filaments, which extends into the terminal web of the cell. A granular matter, probably mucopolysacharide, coats the microvilli. Under pathological conditions, the microvilli display considerable activity and irregularity of size and shape **(Friedmann and Bird, 1971).**

Mucous
Nasal fluid is a mixture of mucous from goblet cells, and seromucus glands, serous material secreted from the anterior serous glands, a transudate from plasma, condensed water from the expired air, tears, cells and microorganisms. This mucous blanket is so thin, made up of two layers superfacial, dense, gel layer and deep, fluid, sol layer. The cilia touch the gel layer, only with their tips, during forward movement. **(Mygind, 1979)**
The amount of mucous and its properties influence the resistance to airflow and thus the pattern of deposition of inhaled particles. Airway mucous consists of free water (94%),bound water(1%),dialyzable materials(1%), and macromolecules(4%)such as,glycoprotein,proteins and lipids**.(Lopez-Vidriero,1981).**
The mucous blanket contains various defense factors. The surface tension, which is dependant upon the viscosity of the mucous, opposes the penetration of the particles. Other biological factors include immunoglobulin, interferon and lysozymes **(Hisaamtus et al., 1986).**

Physiology of the Inferior Turbinate

Although the nose is a paired structure divided sagittaly into two chambers it acts as a functional unit. An understanding of the physiological facts of the normal nasal function will prevent unnecessary surgery to the septum and turbinates **(Drake – Lee, 1997).**

Physiological function of the nose:

- Olfaction
- Respiration
- Heat exchange
- Humidification
- Filtration
- Nasal resistance
- Nasal fluids and ciliary function
- Nasal neurovascular reflexes
- Voice modification

(Drake – Lee, 1997).

Nasal airflow

Airflow occurs through the nose if there is difference in pressure across the nasal airways with the airflow occurring from the area of higher pressure to the area of lower pressure. Although the pressure outside the nose is relatively constant, the pressure in the nasopharynx changes with respiratory movement of the chest. This change create a pressure difference (transnasal pressure) across the nose and air moves back and front through the nose with the phases of respiration **(Pallanch, et al., 1998).**

Physical factors affecting the amount of airflow:

The rate of airflow through the nose depends on the length and cross – sectional area of nasal airway, the pressure gradient across the nose, and the character of the airflow (laminar versus turbulent). The cross-sectional area of the nose is a major factor in determining airflow, with airflow increasing as the cross-sectional area increases. The cross-sectional area varies along the length of the nose. The effect of turbulence in the nasal airway has not been precisely quantified. Laminar flow occurs in a smooth-walled, straight tube at low flow rates, but turbulence occurs when irregularities are encountered in the tube, as would happen in the nose. Turbulent flow requires more energy but results in better mixing of the air thus, enhancing nasal function **(Pallanch, et al., 1998).**

Airflow pattern

The basic of the airflow has been studied by **Scherer et al., (1989)**. They concluded that inspiratory air current is directed upwards and medial to the anterior end of the turbinates by the relatively small anterior nares, placed horizontally. The air current fans out as they reach the wide preturbinal area. The inspiratory air then passes in a narrow stream medial to the middle turbinate and then downward upward in a high vaulted curve. The stream fans out as it traverses the posterior choana and unites the stream from the other side to make a single one. It then makes a sharp turn downwards to pass through the pharynx and then forward to enter the larynx. Expiratory air currents enter the choanae from the nasopharynx and follow much the same route in an opposite direction as to the inspiratory air currents. Anteriorly on meeting the constriction on the upper limit of the vestibule, the air currents divide, a portion passes through the vestibule and the remainder forms a large central eddy whirling back through the inferior meatus and rising to join the main stream from the nasopharynx. Part of the central eddy passes under the middle turbinate **(Scherer, et al., 1989).**

Nasal resistance

There was tendency among rhinologic surgeons to view the nose as a passive conduit between the outside and the pharynx that must be enlarged to accommodate a maximum amount of airflow. On the contrary, the nose functions by acting as a variable resister to airflow **(Williams, 1970).**

The nose has a resistance to airflow higher than that of the remainder of the respiratory passages combined **(Haight and Cole, 1983).**

Two resistors in parallel produce nasal resistance and each cavity has a variable resistance valve as result of the nasal cycle. The resistance is made of two elements. The first is the bone, cartilage, and attached muscles, while the second is the mucosa. The narrowest part of the nose is the nasal valve, while physiologically, is less well defined than the anatomical structures, which constitute it. It comprises the lower edge of the upper lateral cartilage, anterior end of the inferior turbinate and the adjacent nasal septum, together with the surrounding soft tissues. As the anterior valve is the narrowest part of the airway, it is one of the main factors in promoting turbulent airflow since it is the largest resister in the whole airway **(Bridger and Proctor, 1970).**

The resistance to nasal airflow is important in nasal function. It generates the turbulent airflow that allows the interaction between the air stream and the nasal mucosal surfaces **(Kimmelman, 1989).**

The nasal resistance is high in infants, as they are obligate nose breathers at least initially. Adults breathe preferentially through the nose at rest