
Outcome assessment of 603 cases of concomitant inferior turbinectomy and Le Fort I osteotomy

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This retrospective study assessed the outcome of 603 patients undergoing partial inferior turbinectomies (PIT) in association with Lefort I osteotomy. The study included 1234 patients from a single private practice; these patients had dentofacial deformities and underwent Lefort I osteotomy procedures. For the full patient group, 888 patients (72%) were women; in the turbinectomy group, 403 (67%) were women. The anteroposterior, transverse, and vertical dimensions of the mandible, maxilla, and occlusal plane of each subject were assessed, in addition to cephalometric analysis and determination of the presence or absence of temporomandibular joint disorders. PIT, when indicated, was performed after downfracture of the maxilla, providing access to the turbinates where approximately two thirds of the total turbinate volume was removed and septoplasty was completed if indicated. Hypertrophied turbinates causing significant nasal airway obstruction were present in 603 (49%) of the 1234 patients undergoing Le Fort I osteotomy. The results of this study showed that PIT performed simultaneously with Le Fort I osteotomy is a safe method of managing nasal airway obstruction related to hypertrophied turbinates with minimal complications.

The nasal turbinates or conchae are curled thin bone shelves that protrude from the lateral nasal walls medially into the nasal breathing passage covered with glandular, erectile, and mucosal tissues. Three turbinates are arranged in horizontal parallel rows on each side of the nose. The inferior turbinate is the largest, followed by the middle, and the superior turbinate is the smallest. The turbinates divide the nasal airway into four air passages, which guide the inhaled air to flow in a steady stream around the largest possible surface of cilia. In the presence of normal anatomy, the inferior turbinates play a major role in filtering, warming, and humidifying the nasal airway, with approximately 80% of the airflow occurring around the inferior turbinates. The sympathetic and parasympathetic nervous systems are responsible for change in the turbinate size according to physiologic requirements (1). This is a cyclical set of events, which is affected by increasing or decreasing the volume of blood contained in the associated erectile tissue.

Large or swollen turbinates may lead to decreased air flow through the nasal passage. Allergic exposure to environmental elements and allergens, in addition to persistent inflammation within the sinuses, can lead to turbinate swelling. Anatomical

and traumatic factors can also play a role in this process. Deformed and enlarged inferior turbinates are the main causes of nasal airway obstruction, followed by allergic rhinitis (2, 3). Epidemiologic studies in European countries have shown that up to 20% of the population has chronic nasal obstruction caused by turbinate hypertrophy (4). The most common causes of hypertrophied turbinates are allergic and nonallergic nasal hyperactivity, followed by septal deviation (5). The sequela of chronic nasal obstruction is mouth breathing, which results in a lower and anteriorly placed tongue and a lower position of the mandible. This consequently decreases the tonicity of the facial muscles as a result of decreased flow of the nasal airway due to anatomical obstruction (6–8). Based on functional matrix theory, put forth by Moss et al (9), the lack of nasal breathing can significantly affect the development of dentofacial and craniofacial structures. In an individual with obstructed nasal airway, disharmony of normal breathing and abnormal tone and stimulation of facial muscles could be the cause of a narrow and posteriorly positioned mandible, in addition to a hypoplastic maxilla, associated with open bite (10–12).

The allergic turbinate hypertrophy can be managed with medications, such as corticosteroids, and if this approach fails, surgery may be necessary (13). When a deviated septum is identified, the turbinate associated with the affected side is usually enlarged. In such cases, the septum can be addressed along with the enlarged turbinate. Chronic nasal stuffiness, caused by perennial allergic rhinitis, is amenable to turbinate surgery (14).

Multiple surgical modalities have been advocated to address the hypertrophied turbinate, including turbinate outfracture, electrocautery, reduction by a microdebrider, cryosurgery, coablation, laser reduction, partial or total turbinate resection, use of radiofrequency, submucous turbinate resection, and vidian neurectomy (13, 15–19). The aim of this retrospective study was to perform an outcome assessment of partial inferior turbinectomies (PIT) performed simultaneously with Lefort I osteotomies and analyze the related data for complications, gender

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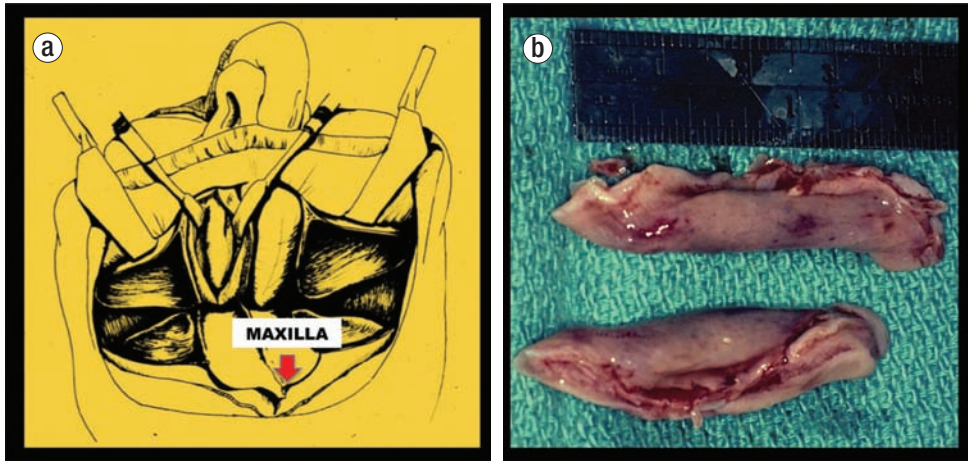


Figure 1. (a) The maxilla has been downfractured (arrow) and an incision made through the nasal mucoperiosteum to expose the right inferior turbinate. (b) The partial resection of the bilateral inferior turbinates has been completed.

distribution, and morphological association with the maxilla and mandible.

METHODS

A retrospective study was conducted on 1234 consecutive patients (888 women, 346 men) from the senior author's (Wolford) private practice (Dallas, Texas) undergoing Le Fort I osteotomy from 1995 to 2011. These patients required Le Fort I osteotomies for correction of dentofacial deformities, and a significant number of patients also required temporomandibular joint (TMJ) surgery. Institutional review board exemption was obtained.

The surgical technique for PIT was as follows. In the maxillary osteotomies, prior to mobilization, the nasal mucosa was carefully dissected off the nasal floor, the lateral nasal wall up to the base of the inferior turbinate, and off the inferior aspect of the nasal septum. The septum was separated from the maxillary nasal crest. The maxilla was downfractured and mobilized, with care taken to preserve the nasal mucosa intact. Using a 15 blade, an incision was made bilaterally, just lateral to the septum, extending from the posterior to the anterior aspect of the nose. Retracting the mucosal tissue laterally exposed the entire body of the turbinates (*Figure 1a*). The portion of the turbinates to be resected was isolated and excised using scissors (*Figure 1b*). Hemostasis was achieved using a Bovie cautery. If a nasoseptoplasty was indicated, the mucosa was dissected off the septum and an appropriate procedure performed to correct the septal deformity. The nasal mucosa was approximated using 4.0 chromic gut sutures in a running fashion, incorporating all four mucosal flaps. Postsurgical imaging on a typical patient demonstrated the reduced turbinates (*Figure 2c, 2d*).

There were three diagnostic criteria for hypertrophic turbinates: 1) a history of consistent difficulty breathing through the nose; 2) clinical and radiographic evidence of the turbinates blocking the majority of the nasal airway; and 3) predominant mouth breathing when sleeping. Evaluations included medical history; clinical assessment; standardized x-rays; dental models; clinical pictures; morphological evaluation of maxilla, mandible, and occlusal plane angle; evaluation of external and internal

nasal deformities; and determination of any current respiratory problems. In cases prior to 2008, radiographic images were obtained with the Quint Sectograph, and after 2008 with cone beam computed tomography (CT) scan. These radiographs were taken in the normal course of patient treatment.

Lateral cephalograms, anteroposterior radiographs, and cone beam CT scans were analyzed to determine the transverse, vertical, and anteroposterior dimensions of the maxilla and mandible as well as the occlusal plane angulation. The maxilla and mandible were categorized

into hypoplastic, hyperplastic, and normal groups. The occlusal plane angle was labeled as normal, low, or high angle.

The total patient group ($n = 1234$) was also evaluated for the presence of and correlation between hyperplastic turbinates and TMJ surgery. The TMJ surgeries performed included TMJ disc repositioning using the Mitek anchor technique (Mitek Inc, Norwood, MA) and TMJ reconstruction using TMJ Concepts (Ventura, CA) total joint prostheses. The gender variation and correlation to PIT were evaluated. Descriptive statistics and Pearson's correlation analysis were utilized to evaluate the results.

RESULTS

Among the 1234 patients enrolled in the study, 888 (72%) were women, and 346 (28%) were men. In 603 cases (49%), partial turbinectomies were required. In this subgroup, 403 (67%) were women and 200 (33%) were men (*Table 1*). A total of 278 patients (23%) required septoplasty. The mean age of the patients at surgery was 28 years (range, 13–58 years), and the average follow-up period was 24 months (range, 12–48 months). *Figures 2 to 4* illustrate results from typical patients.

The morphological characteristics of the maxilla and mandible were independently evaluated by clinical study models and cephalometric analysis. For patients who required turbinectomies, 84% had maxillary hypoplasia in the anteroposterior dimension, 52% in the transverse dimension, and 48% in the vertical dimension. The mandibular morphological association with PIT included mandibular hypoplasia in the anteroposterior direction (72%) with normal transverse (97.9%) and vertical (94.9%) dimensions (*Table 2*). The anteroposterior hypoplastic maxilla and anteroposterior hypoplastic mandible had a strong morphological association with hypertrophied turbinates ($r = 0.95$; $P < 0.05$) (as illustrated in *Figures 3a–3c, 4a–4c*). In 69% of high occlusal plane angle cases, there was a strong correlation with hypertrophied turbinates (*Figure 5a*). The remaining cases had a normal occlusal plane angle (27%), with only 4% associated with a low occlusal plane angle (*Table 2*).

Of the 603 patients, 296 (49%)—including 215 (73%) women and 81 (27%) men—received concomitant TMJ surgery, Lefort I osteotomy, and PIT. The remaining 307 patients—188

(61%) women and 119 (39%) men—received PIT and Lefort I osteotomy with no TMJ surgical intervention (*Table 1*).

All the patients were followed immediately postoperatively and at long-term follow-up of 12 to 48 months. Chart review showed no significant long-term complications associated with PIT.

DISCUSSION

Hypertrophied turbinates can be addressed with various means, from conservative therapy (20) to surgical modalities. In

Table 1. Patient gender by procedure

Procedure	Male	Female
Lefort I osteotomy and PIT (N = 603)	200 (33%)	403 (67%)
Subgroup with no TMJ surgery (N = 307)	119 (39%)	188 (61%)
Subgroup with TMJ surgery (N = 296)	81 (27%)	215 (73%)

PIT indicates partial inferior turbinectomies; TMJ, temporomandibular joint.

Table 2. Skeletal morphological characteristics that correlate with turbinate hyperplasia

	Anteroposterior	Vertical	Transverse
Maxilla			
Normal	12%	13%	45%
Hypoplasia	84%*	48%	52%
Hyperplasia	4%	39%	3%
Mandible			
Normal	10%	95%	98%
Hypoplasia	72%*	2.5%	0.8%
Hyperplasia	18%	2.5%	1.2%
Occlusal plane			
Normal	27%		
Low	4%		
High	69%*		

* $P \leq 0.05$.

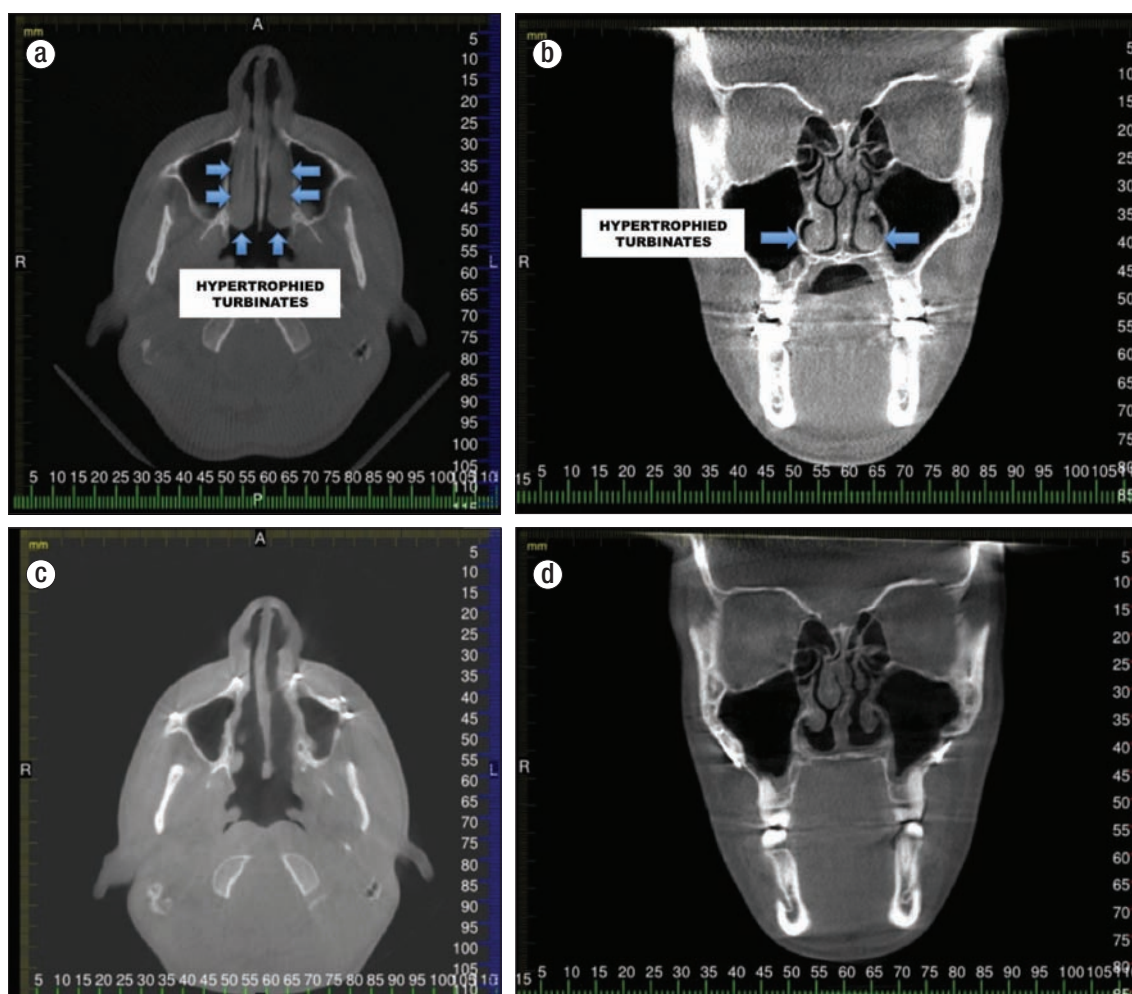


Figure 2. Computed tomography scans of a typical patient before and after the procedure. **(a)** Axial view demonstrates hypertrophied turbinates (arrows) and the nasal septum that appears reasonably straight. **(b)** Coronal view demonstrates hypertrophied turbinates (arrow) occupying the majority of the nasal cavity. **(c)** After turbinectomy, along with the maxillary osteotomies, the axial view shows the patient's improved nasal airway. The cut is just inferior to the remaining turbinates. **(d)** Coronal view shows the reduced turbinates and improved nasal airway.



Figure 3. (a–c) A typical patient with hypertrophied turbinates associated with a retruded maxilla and mandible and high occlusal plane angle facial morphology. (d–f) The patient seen after surgery, which included TMJ reconstruction as well as mandibular and maxillary advancement in a counter-clockwise direction, genioplasty, and partial turbinectomies.

patients with dentofacial deformities, the Le Fort I osteotomy provides direct access to the full extent of the inferior turbinates and the septum. The patients in this study with hypertrophied turbinates were treated with PIT in combination with maxillary and mandibular osteotomies with correction of the occlusal plane to a normal angulation as well as TMJ surgery when indicated to provide optimal function, facial balance, decrease in pain, and good airway (Figure 3d–3f, 4d–4f, 5b). A female predominance was seen in the data reviewed. Approximately 67% of the turbinectomy cases, and 73% of concomitant turbinectomy and TMJ surgery cases, involved female subjects. A strong correlation has been established between hypertrophied inferior turbinates, hypoplastic maxilla and mandible, as well as a steep occlusal plane. Our findings correlate with other studies evaluating the morphology of mouth breathing and nasally obstructed patients (6, 21–23).

The association of mouth breathing, dentofacial deformities, and upper airway obstruction has been explored in the orthodontic, otolaryngology, and maxillofacial surgery literature (24). It still remains a controversial subject with no general consensus achieved (25–28). Harvold et al (29), in their primate studies, induced obstruction of the nasal airway and generated morphological changes in dental and craniofacial parameters. McNamara (30) proposed a physiological mechanism that

describes the association of upper respiratory obstruction and changes in the neuromuscular system that alters the bony, soft tissue, craniofacial, and dental structures.

When addressing hypertrophied turbinates along with correction of dentofacial deformities, especially in the case of performing Le Fort I osteotomies, postsurgical patency of the airway should be considered (31–33). When the Le Fort osteotomy is performed, the maxilla can be mobilized, repositioned, and stabilized in any of four possible directions, affecting the associated and adjunctive soft tissues (34). In 1997 Kunkel and Hochban (35) utilized the acoustic rhinometry concept introduced by Hilberg et al in 1989 (36) to evaluate the effect of maxillary movement on the nasal volume. Erbe et al in 2001 completed acoustic and rhinometry evaluation of 21 maxillary advancement and impaction cases and concluded that in anterior and superior maxillary repositioning, there was no significant change in airflow resistance (37). Haarmann et al (2009) investigated the changes in nasal airways after Le Fort I osteotomies with concomitant nasal septoplasty and

inferior turbinectomies using anterior rhinomanometry and acoustic rhinometry. The results of their analysis supported the improvement of the functional airway after surgery (38).

The simultaneous reduction of inferior turbinates is of importance in cases requiring maxillary superior repositioning for management of upper airway obstruction in the presence of hypertrophied turbinates. Multiple publications have addressed and reported case series on the subject (38–40).

In the reviewed sample size ($n = 603$), no significant long-term postsurgical complications related to the nasal airway were identified. The most common complications from turbinate surgery are hemorrhage, atrophic rhinitis, and ozena (41). The reduction of the appropriate volume of the inferior turbinate is of importance, taking into account the presented histological factors and maintenance of mucociliary function. The resection of the entire turbinate increases the patency of the nasal airway but increases the chance of intraoperative and postoperative heavy bleeding, while having a long-term chance of chronic nasal crusting (42–44).

Presently there is no exact consensus on the volume of reduction or the method utilized for PIT. Based on this case series, clinical outcomes, and preservation of the function of the nose, the recommended reduction of the hypertrophied inferior turbinates should equal about two thirds of the original

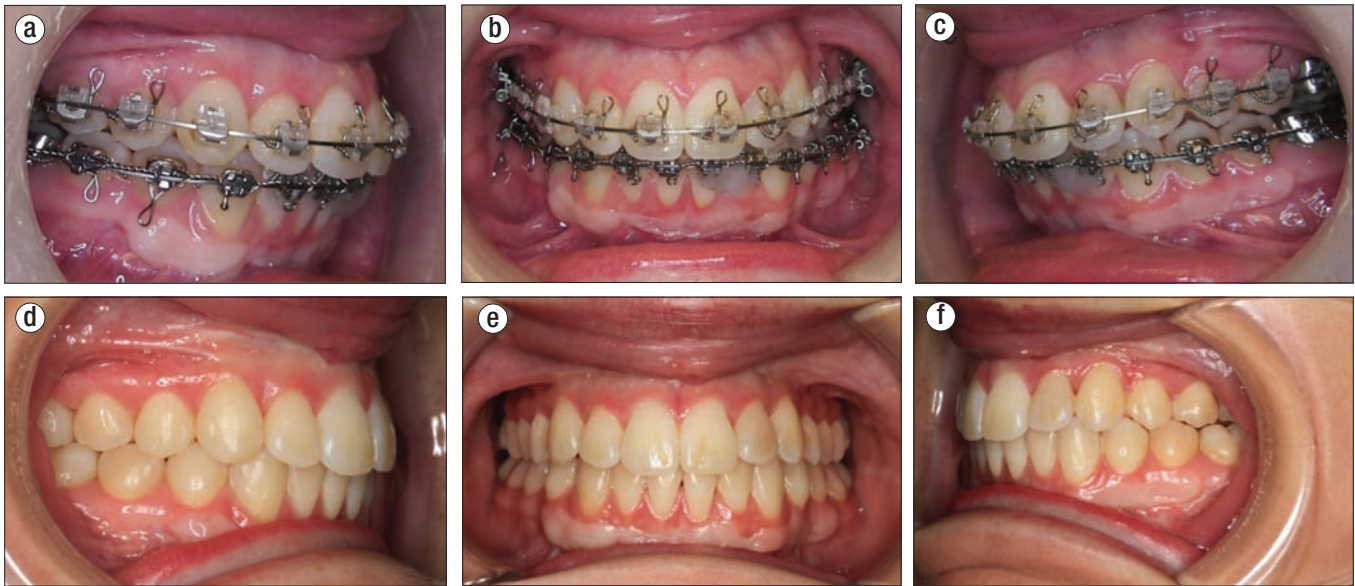


Figure 4. (a–c) The patient has a high-angle Class II end-on occlusion before surgery. (d–f) After surgery, the patient has a good functional occlusion with a decreased occlusal plane angle.

volume (45–47). Excessive reduction of turbinate tissue could cause the rare empty nose syndrome (ENS). ENS is associated with poor regrowth of sensory nerves, which are damaged during aggressive turbinectomies. In ENS, the nasal airway is unobstructed, but the affected patients sense an unsatisfactory struggle to breathe (48, 49). Ear, nose, and throat specialists presently believe that ENS is a diagnosis with no criteria for its identification and in general recommend conservative reduction of the turbinates for its prevention (50).

In conclusion, PIT is a predictable and safe procedure performed simultaneously with Lefort I osteotomy for patients identified with hypertrophic inferior turbinates and nasal airway obstruction. A notable pattern was established in our patient population, which clinically associates female patients with high

occlusal plane, hypoplastic maxilla, and mandible complex as the predictable group for hyperplastic turbinates requiring PIT. In assessing this study, it is important to understand that most patients associated with the senior author's practice are retrognathic patients, with associated TMJ disorders, which could have an effect on the patient sample. The relation between TMJ disorders and hypertrophied turbinates is also noteworthy, and a larger multicenter controlled group will be necessary for establishing its implication. Our recommendation is that in patients with dentofacial deformity undergoing Le Fort I osteotomy, the general status of the patients' breathing and nasal structures should be taken into consideration for concomitant surgical intervention.

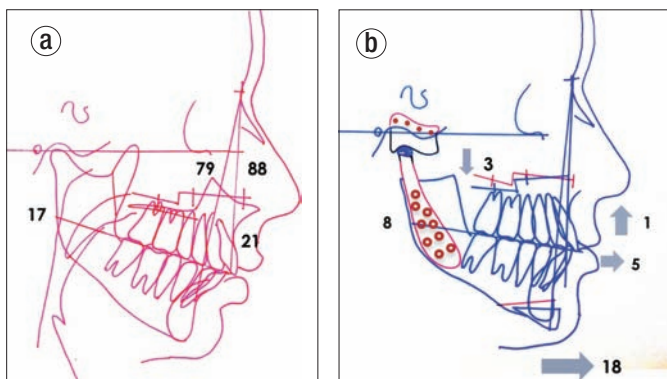


Figure 5. (a) The lateral cephalometric tracing illustrates typical facial morphology with hypertrophied turbinates, including a retruded maxilla and mandible and a high occlusal plane angle. (b) The treatment plan for this patient included maxillary and mandibular counter-clockwise rotation with reconstruction of the TMJs with total joint prostheses as well as bilateral partial inferior turbinectomies and genioplasty. The chin point advanced forward 18 mm, improving the patient's profile as well as significantly improving the functional airway.

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