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Septal cartilage reshaping with the use of an Erbium doped glass fiber laser. Preliminary results*

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SUMMARY

Statement of problem: *To evaluate the efficacy of Erbium doped glass fiber laser in patients undergoing nasal septal cartilage reshaping.*
Method of study: *A prospective study was conducted in patients undergoing laser nasal septal cartilage reshaping. Microsurgical sponges soaked in a tetracaine solution plus adrenaline were applied in each side of the nose for ten minutes before the procedure. The cartilage of nasal septum was straightened and fixed in the median position using a modified nasal speculum. An optothermomechanical contactor with transparent indenter and thermocouple sensor was placed on septal regions of maximum mechanical stress. Patients were asked to evaluate the severity of pain during the procedure on a visual analog scale. A rhinomanometric evaluation was conducted preoperatively and postoperatively. All patients were asked to evaluate the improvement of their symptoms. All patients' data and potential complications were entered in a database and were statistically assessed.*
Main results: *Our series consisted of 64 patients. Statistical analysis showed significant improvement of their symptoms and of rhinomanometric results. No complications or side effects occurred. The mean operative time was 35 minutes.*
Principal conclusion: *Septal cartilage reshaping is an easy painless and bloodless method using en Erbium doped glass fiber Laser. Laser device LSC-701 (Arcuo Medical Inc.) is effective, safe and inexpensive medical equipment.*

Key words: cartilage reshaping, laser reshaping, stress relaxation, laser modification, laser erbium

INTRODUCTION

Nasal obstruction is a common symptom in otolaryngology practice. Nasal septum deviation is a common etiology although nasal obstruction can be caused by other conditions, such as inferior turbinate or adenoid hypertrophy, nasal valve dysfunction, choanal atresia as well as nasal polyposis and tumours. Moreover, it is estimated that as many as 75% to 80% of individuals exhibit some type of anatomic deformity of the nose (1). Up to now, surgical correction of the deviated septum has been the definitive treatment for septal deviation.

Deformity and destruction of septal cartilage resulting from trauma, disease or ablative surgery represent a reconstructive challenge for the head and neck surgeon (2-6). In previous studies we used a carbon dioxide Laser to heat the cartilage to a temperature of 65°C to 75°C, resulting in increased malleability and allowing shape change (7-11). The apparent clinical applications for facial laser cartilage reshaping in the head and neck region have generated increased clinical interest. More recent works have identified and described this mechanical stress relaxation effect in cartilage tissues exposed to non-ablative laser irradiation, providing an impetus for the development of plastic surgical procedures in the head and neck (12).

No studies regarding the use of Laser Erbium in septum cartilage reshaping procedures have been reported so far. We evaluate the efficacy of Erbium doped glass fiber laser in patients undergoing nasal septal cartilage reshaping.

MATERIALS AND METHODS

Clinical study

A prospective study was conducted between January 2007 and June 2007 at the Department of Otolaryngology, School of Medicine, University of Crete, in patients undergoing nasal

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Figure 1. The Erbium doped glass fiber Laser, wavelength 1.56 m and power 4.1 W (LSC-701 device - Arcuo Medical Inc).

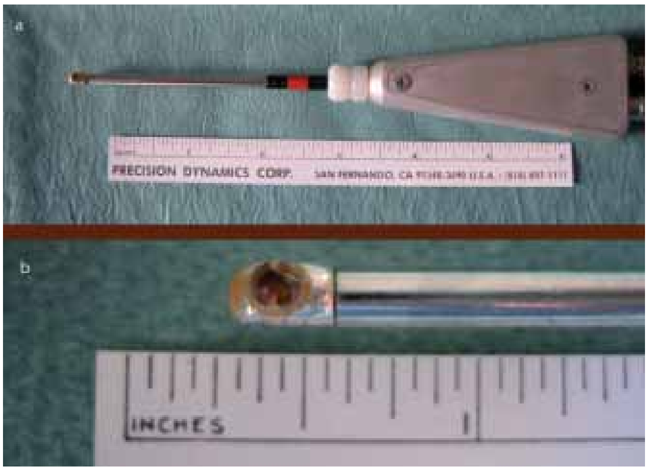

Figure 2. a) The erbium optothermomechanical contactor. b) The sapphire indenter with two-thermocouple sensor at the distal end of the optical fiber.

septal cartilage reshaping with the use of an Erbium doped glass fiber Laser at a wavelength of 1.56 μm and power of 4.1 W (LSC-701 device - Arcuo Medical Inc) (Figure 1). Indications for Laser nasal septal cartilage reshaping included septal cartilage deviation (area 1,2,3 according to Cottle)[13] as well as minimal postoperative deviation after septal surgery. We excluded from the study all patients with horizontal or vertical fracture or patients on anxiolytic, hypnotic or antidepres-

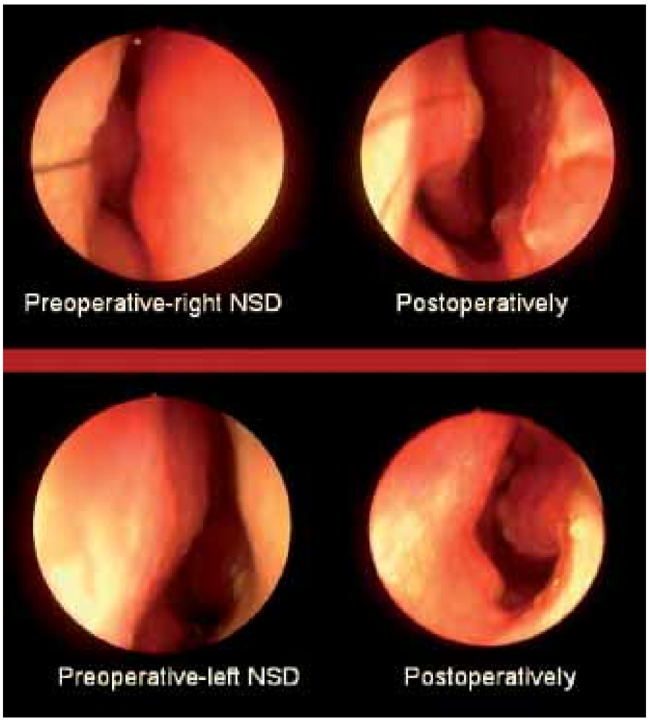

Figure 3. Intranasal view of septal cartilage preoperative as well as one month postoperatively.

sant medication. All patients were operated under local anesthesia, with the same technique. Three microsurgical sponges soaked in a tetracaine solution plus adrenaline were applied in each side of the nose for ten minutes prior to the procedure. The operating time was measured from the onset of local anesthesia to the end of the procedure. An optothermomechanical contactor with a sapphire indenter was used (Figure 2). Postoperatively, a small anterior nasal packing with a 2% sodium fucidate gauze was placed at the side of septal deviation for 24 hours. Patients were requested to evaluate the intensity of pain experienced during the procedure 24 hours after surgery using a visual analogue scale of 0-10, where 0 = no pain and 10 = intolerable pain.

Rhinomanometry

An active anterior rhinomanometric examination was performed in order to determine unilateral nasal resistances preoperatively as well as three months postoperatively. The nose was decongested after each rhinomanometric measurement with two vaporizations with 0.1% Oxymetazolin spray in each side and the test was repeated after 10 minutes. We used nasal resistance values in the decongested state to minimize the influence of mucosal variations allowing the assessment of the skeletal component of nasal airway resistance. Nasal airflow (cm^3/s) and resistance ($Pa/cm^3/s$) measurements were taken in each subject. Mean airflow and resistance were measured in each nostril at pressures of 75, 150 and 300 Pa following decongestion and the relevant curves were obtained.

Table 1. NOSE score, nasal airflow & resistance measurements prior and after laser treatment.

	Before		After	
	Mean (SD)	Median	Mean (SD)	Median
NOSE score	17 (3.2)	17	10 (4.0)	10
Airflow (cm^3 s^{-1})				
Left nostril	217 (126.6)	194	266 (137.2)	248
Right nostril	198 (127.2)	165	241 (122.6)	228
Sum	411 (161.3)	391	509 (200.9)	482
Resistance				
Left nostril	1.50 (2.03)	0.91	1. 01 (1.14)	0.62
Right nostril	1.73 (1.89)	1.18	1.19 (1.16)	0.91
Sum	3.22 (2.50)	2.45	2.20 (1.55)	1.84

Table 2. Change in NOSE score, nasal airflow & resistance measurements following the laser procedure.

	Mean	95% CI		p-value
		Lower limit	Upper limit	
NOSE score	6.7	5.7	7.7	<0.0001
Airflow (cm3 s-1)				
Left nostril	-49.1	-65.1	-33.2	<0.0001
Right nostril	-43.1	-65.2	-20.9	<0.0001
Sum	-94.5	-124.9	-64.9	<0.0001
Resistance				
Left nostril	0.49	0.20	0.77	<0.0001
Right nostril	0.54	0.27	0.81	<0.0001
Sum	1.03	0.66	1.39	<0.0001

Recorded data

In addition, patients completed the Nasal Obstruction Symptom Evaluation (NOSE) scale, which is a subjective measure of health status, with possible scores ranging from 0 to 20. Higher scores imply a greater subjective degree of obstruction (5 questions each rated on a 5-point Likert scale) [14]. Other recorded variables were age, sex and the side of nasal septal deviation (NSD) (left/right). Intranasal figure was recorded preoperative as well as one month after the procedure (Figure 3). The patients' data, rhinomanometric measurements and NOSE scale evaluations were entered in a database. All data was statistically assessed using the SPSS software Ver 14. This study was approved by the local ethics committee, and the National Pharmaceutical Organization (Greek FDA).

RESULTS

Our series consisted of 67 patients, 49 (73%) male and 18 female (27%), ratio 2.72/1. The mean patient age was 44 (SD 13.9) years. Following the procedure, the average NOSE scores, flow measurements and resistance measurements were found to be significantly improved to a statistically significant extent ($p < 0.0001$) (Tables 1 and 2). The mean operative time was 35 minutes. No intra-operative pain was recorded. No postoperative haemorrhage or other complication occurred. No patient was lost to follow up. No visible mucosal thermal changes were noticed.

DISCUSSION

Physicians are often confronted with the question of whether or not a septal deformity is the main cause of nasal obstruction. Surgeons often rely on their subjective assessment regarding the severity of nasal obstruction to decide on therapeutic management, which often involves surgery. It is, therefore, not surprising that some investigators criticize the number of unnecessary septoplasties performed each year [15]. Modern functional septoplasty was introduced and developed by Cottle during the late 1950's. The method, which involves a hemitransfixion incision, preparation of the premaxilla and access to the septal cartilage through tunnels utilizes almost the same approach for different types of deviation.

Cartilage is an ancient biological tissue; it existed in some of the earliest organisms. Cartilage acts as a shock-absorbing tissue, which mechanically connects, supports and maintains various other tissues and organs. Cartilage contains neither nerves nor blood vessels and is an ideal material for transplantation. Because cartilage possesses high internal stress and exhibits shape memorization, it has been difficult to achieve permanent change in cartilage shape. We have reported the results of early experiments in changing the shape of cartilage using non-destructive laser irradiation [9]. The ideal procedure involves irradiation of the area of maximal stress in order to produce stress relaxation resulting in a new cartilage shape [13,16].

The optical properties of nasal septal cartilage at room temperature have been studied in the near infrared region using integrating spheres [17,18]. Moreover, pulsed photothermal radiometry has been applied to study the effect of free electron laser radiation on the absorption coefficients of cartilage and cornea [19,20]. The dynamics of 1.56 μm laser light transmission through cartilage is also studied as a function of mechanical load. Mechanical loading (compression) was applied to a nasal cartilage slab in the direction of laser irradiation. The incident fluence of laser light was kept small (of 0.5 W/cm^2) to avoid any thermal-induced effects (the temperature increase was less that 1°C). The mechanical deformation of the cartilage sample was approximately linear with mechanical load increasing from 50 to 250 g. The deformation was 0.22 mm (15%) at a load of 250 g. The effect of mechanical load increases transmission up to 20 percent. Since 1.56 μm radiation is absorbed mainly by water, the observed alteration in cartilage absorption can be attributed to alterations in water content in the mechanically loaded cartilage. Thus, mechanical loading removes water from superficial layers of cartilage, decreases light absorption in the superficial layer shifting peak temperature increase to deeper areas in the cartilage.

A similar study was performed with use of a YAG Laser (wave-length 2.09 μm, pulse duration 500 msec, pulse energy 0.2-0.4 J and pulse repetition rate 5 Hz) [21]. One hundred ten patients aged 11 to 66 years old were underwent laser septochondrocorrection in this study. Eightyfour patients (76%) showed stable improvement in nasal obstruction and disappearance of the attendant symptoms. Nevertheless, laser septochondrocorrection was performed in 11 children and adolescents. The procedure was well tolerated and no complications were observed.

During the procedure with the Erbium Laser device LSC-701 (Arcuo Medical Inc.) an optothermomechanical contactor with transparent indenter and thermocouple sensor is placed at the distal end of the optical fiber. When the contactor is inserted into the patient's nostril, the indenter compresses the nasal septum to extrude some water from the mucosa decreasing light absorption and preventing overheating and destruction. Septal regions of maximum mechanical stress are treated by laser irradiation. The temperature of cartilage is recorded by the feedback control system. Laser radiation is automatically switched off at the attainment of a preset temperature. Preset temperature is selected (depending on the type of the contactor and laser fluence) at 40-42°C at the periphery of the laser spot and about 55-60°C at the centre of the laser spot on the irradiated surface of septal cartilage. The irradiation of each spot takes a few seconds and does not damage the superficial tissue or the perichondrium.

The new Erbium doped glass fiber laser of a wavelength of 1.56 μm could reshape deformed nasal cartilage without injuring the septal mucosa. This non-destructive laser reshaping can potentially become a novel application of laser in otolaryngology and, in selected cases, replace the conventional traumatic methods. The ideal indication for this procedure includes C-shape septal cartilage deviation (area 1,2,3) and minimal cartilage deviation after septal surgery. It is also very useful when is combined with turbinate reduction in case of inferior turbinate hypertrophy. For patients with mild or severe bony deviations of the septum this method is useless. It is a minimally invasive, bloodless, easy to perform outpatient procedure and can be performed under local anesthesia. The mean operative time excluding anesthesia is 25 minutes but we believe that in the future, after patient data has been determined, the operation time can be shorter. It can also be applied to a wider age range than the conventional method and is almost free of complications.

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Septal cartilage reshaping using an Erbium doped glass fiber is a modern, promising, safe, painless and bloodless surgical procedure that requires 20-25 minutes to complete and can be performed in an outpatient environment.

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