Deleterious effect of smoking and nasal septal deviation on mucociliary clearance and improvement after septoplasty

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ABSTRACT

Objectives: To investigate the effect of septal deviation, septoplasty, and smoking upon nasal mucociliary clearance by using saccharine test.

Methods: Included in this study were 40 patients (15 women and 25 men) who had septal deviation and septoplasty surgery performed between March and June 2006. Patients are classified into three groups: group I (n = 20) nonsmoking patients who had septoplasty surgery, group II (n = 20) smoking patients who had septoplasty surgery, and the control (n = 20) group. None of the control group has nasal breathing problem or smoking history. For determining preoperative and postoperative nasal mucociliary clearance (MCC) time, a saccharine test was performed on the patients 1 day before surgery and at the third month of postoperative control.

Results: Preoperative and postoperative nasal MCC time in patients of group I are statistically significantly lower than the group II (p < 0.01). Postoperative MCC time in group I and II is significantly decreased compared with preoperative MCC time, statistically (p < 0.01). Preoperative and postoperative MCC time of group I and group II is significantly higher than MCC time of the control group (p < 0.01).

Conclusion: Nasal septal deviation and smoking deteriorates nasal MCC time and this result can be shown easily with the saccharine test. Properly performed septoplasty surgery decreases nasal MCC time during the late postoperative period but MCC times are still longer than normal. The saccharine test can be used for following up the effect of septoplasty upon nasal mucosa.

Key words: Nasal mucociliary clearance, postoperative, preoperative, saccharine test, septal deviation, septoplasty, smoking

Cleaning foreign particles over respiratory mucosa and keeping this mucosa moist are necessary for normal physiology of the nose. These abilities of respiratory mucosa depend on effective ciliary activity and renewing of airway secretions. These are together known as mucociliary activity. It is known that long-term smoking causes an alteration in mucociliary clearance (MCC) by decreasing normal cilia population and impairing viscoelasticity of mucus. Nasal septal deviation alters nasal physiology by causing obstruction. In addition, deviation distorts MCC by increasing mucus secretion, effecting normal ciliary movement, and causing airway epithelium damage. The first defense mechanism for the airway is at the nasal fossa mucosa. This mechanism depends on the synergia of mucus and cilia, which create MCC. Technological improvements have made it possible for us to determine the nasal dynamic phenomena such as nasal transport function abnormalities within the past 20 years. Surgery is the only curative treatment for nasal septal deviation. In some literatures it is emphasized that septoplasty effects MCC positively. Alteration on nasal mucosa can be investigated with the following mucociliary function studies:

The photometrical method can be used for measuring ciliary movements by evaluation of cilia beat frequency from randomly selected areas in nasal mucosa. In this method, ciliary movements can be measured away from hormones, inflammatory mediators, and stress.

The MCC test is used to measure the elimination of inhaled aerosols. Saccharine test is one of the methods used for measuring MCC. The electron microscope can be used to evaluate histological properties of cilia. The number of united cilia, central and peripheral microtubulus defect, inner and outer dynein, and ciliary orientation can be investigated in this method.

The purpose of this study is to investigate the effect of septal deviation, septoplasty, and smoking on nasal MCC by using the saccharine test.

MATERIALS AND METHODS

In total, 40 patients (15 women and 25 men) are included in this study who underwent septal deviation and septoplasty surgery between March and June 2006 at the Haydarpasa Numune Research and Training Hospital. Twenty patients had a history of smoking (minimal, 1 pack/day; a history of at least 5 years smoking) and 20 patients did not use cigarettes. Twenty volunteers were chosen as control group and none of them had nasal pathologies or smoking history. We did not encounter any pathologies like septal deviation, rhinosinusitis, nasal polyposis, etc. during the nasal rhinoscopic examination of the control group.

Diagnosis of septal deviation was based on history of patients and complete nasal examination including anterior rhinoscopy and nasal endoscopy (0° rigid endoscope). Patients with conchal hypertrophy, allergic rhinitis, bacterial or viral rhinitis, allergic pulmonary disease, asthma, sinusitis, nasal polyposis, or using drugs (topical or systemic) were excluded from the study. No medical therapy is given at preoperative period. For determining preoperative nasal MCC time, sac-
charine testing is performed on the patients 1 day before surgery.

One milligram per kilogram of pethidine HCl and 0.5 mg of atropine sulfate are given intramuscularly for premedication and Cottle septoplasty surgery is done under local anesthesia on all patients. Twenty milligrams of lidocaine HCl (2%) and 0.0125 mg adrenalin within 1 mL, known as Jetocaine (Adeka, Istanbul, Turkey) solution is diluted at a ratio of 1:2 saline physiological solution and used for local anesthesia. Classic Killian incision was performed and bilateral mucoperichondrium was elevated. After elevation, minimal cartilage excision was made and maxillary crest was excised in all patients. During the 3-month follow-up period none of the patients had septal perforation. The patients did not have any additional nasal surgery (inferior turbinate or sinus) during septoplasty. At the end of the surgery Merocel packs (Medtronic, Mystic, CT) were used in 18 patients and nasal packs were used in 22 patients. Nasal and Merocel packs were removed at the end of 2nd day after surgery. In addition, oral antibiotics were applied for 2 days postoperatively. After nasal packs and Merocel packs were removed saline solution was ordered three times a day for 2 weeks for irrigation of the nose and patients were discharged. All patients were called back for postoperative controls at the 1st week and 1st and 3rd months. All postoperative patients were evaluated with anterior rhinoscopy (0° endoscopy), secretions were aspirated and mucosal synchiae were dissected under local anesthesia during each control. Saccharine test was performed on all patients for determining nasal MCC time at the 3rd month of control and was done while patients were not using saline solutions because they may deteriorate the test results.

Saccharine testing was performed preoperatively and postoperatively on 40 patients who underwent septoplasty surgery. In addition, it was performed on 20 patients in the control group for determining MCC time. Next, average MCC time was calculated in 40 patients preoperatively and postoperatively in groups 1 and 2, and these average values were compared to evaluate the effects of smoking and septoplasty on nasal MCC (Table 1).

Saccharine testing was performed on all patients and the control group for determining nasal MCC time. Patients were evaluated according to their average MCC values to determine if there was any significant difference between the smoking and the nonsmoking group.

### MCC Testing

MCC testing was done under normal room temperature and patients were told to sit comfortably with their heads in a slightly extended position. At first, nasal secretions were aspirated and then a 1 × 1 × 1-mm dimensional (¼ saccharine tablet) saccharine tablet was positioned to the anterior border of the medial surface of the inferior turbinate in the deviated or opposite nasal cavity. Patients were told not to sneeze and not to bend forward during saccharine test. Also all patients were requested to gulp for every 30 seconds and tell whenever they felt the taste. The values were rolled up to the closest half minute and accepted as nasal MCC time.

### Table 1  Evaluation of mucociliary clearance (MCC) preoperatively and postoperatively

<table>
<thead>
<tr>
<th>MCC</th>
<th>Group I (n = 20)</th>
<th>Group II (n = 20)</th>
<th>p#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative</td>
<td>22.50 ± 2.70</td>
<td>26.35 ± 1.78</td>
<td>0.001¶</td>
</tr>
<tr>
<td>Postoperative</td>
<td>13.50 ± 2.26</td>
<td>15.80 ± 1.67</td>
<td>0.001¶</td>
</tr>
<tr>
<td>§Preop-Postop p</td>
<td>0.001¶</td>
<td>0.001¶</td>
<td></td>
</tr>
</tbody>
</table>

*Values are mean ± SD.

#Student’s t-test.

§Paired sample t-test.

¶p < 0.01.

### Statistical Findings

The Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL) for Windows 15.0 program was used for statistical analysis and paired sample t-test was used for comparison of the patients in the same group. Data values are expressed as mean ± SD and Student’s t-test was used for comparison of the quantitative data between the two groups. One-way ANOVA test was used for comparison of the quantitative data between three groups. For the qualitative data comparison chi-square test was used. Differences were considered as significant when p < 0.05.

### RESULTS

Patients were classified into three groups: group I (n = 20), nonsmoking patients who had septoplasty surgery; group II (n = 20), smoking patients who had septoplasty surgery; and control (n = 20) group. The average age of the patients was 32.48 ± 11.47 years (range, 18–57 years). Twenty-two (36.7%) of the patients were women and 38 (63.3%) of the patients are men.

The average age of the 7 female and 13 male patients in group I was 30.65 years (range, from 18–57 years). The average age of the 8 female and 12 male patients in group II was 33.35 years (range, 18–57 years). The average age of the 7 female and 13 male patients in the control group was 33.45 years (range, 19–53 years; Table 2). None of the volunteers in the control group were smokers and none had nasal respiratory complaints.

Statistically, there was no significant difference according to average ages (p > 0.05) and distribution of gender (p > 0.05) between groups. Preoperative nasal MCC time in patients of group I was statistically significantly lower than the preoperative nasal MCC time in group II patients (p < .01). Postoperative nasal MCC time in patients of group I was statistically significantly lower than the postoperative nasal MCC time in group II patients (p < .01).

There was a statistically significant decrease at the postop-
We compared patients in group I with the control group to evaluate the effect of septoplasty in nonsmoking patients on nasal MCC (Table 3). Preoperative MCC time of group I was significantly higher than MCC time of the control group ($p < 0.01$). Postoperative MCC time of group I was significantly higher than MCC time of the control group ($p = 0.001$ and $p < 0.01$). Postoperative MCC time of group I was significantly higher than MCC time of the control group ($p = 0.039$ and $p < 0.05$).

We compared nasal MCC time of group II with nasal MCC time of the control group to determine the effects of both smoking and nasal septum deviation on nasal MCC and to observe the improvement of nasal MCC time with septoplasty surgery (Table 4). Preoperative MCC time of group II was significantly higher than MCC time of the control group ($p < 0.01$). Postoperative MCC time of group II was significantly higher than MCC time of the control group ($p < 0.01$).

We compared preoperative MCC time with postoperative MCC time of groups I and II and the control group to determine the relationship between these values and age (Table 5). In group I there was a 46% positive correlation between age and preoperative MCC time and this relationship was statistically significant ($r = 0.460; p = 0.041; p < 0.05$). Also, there was a 51.3% positive correlation between age and postoperative MCC time and this relationship was statistically significant ($r = 0.513; p = 0.021; p < 0.05$). In group II there was an 84.1% positive correlation between age and preoperative MCC time and this relationship was statistically significant ($r = 0.841; p = 0.001; p < 0.01$). Also, there was a 75.9% positive correlation between age and postoperative MCC time and this relationship was statistically significant ($r = 0.759; p = 0.001; p < 0.01$). In the control group there was a 64.6% positive correlation between age and MCC time and this relationship was statistically significant ($r = 0.646; p = 0.002; p < 0.01$).

## DISCUSSION

MCC is the most important defense mechanism of nasal epithelium. Harmful foreign material is held by this mucus layer and removed from the nasal cavity by ciliary movements. MCC can be effected from environmental heat, moisture, partial O$_2$ pressure, pH, trauma, sulfur dioxide, formaldehyde, ozone, chlorine, smoking, viral infections, chronic sinusitis, chronic and allergic rhinitis, adenoid hypertrophia, cystic fibrosis, chronic bronchitis, septum deviation, surgery, bronchial asthma, and diabetes mellitus.

Smoking is one of the factors that adversely effects MCC by changing viscoelasticity of the mucus layer and showing ciliotoxic effects. Vastag et al. studied 71 smoking patients and found that MCC with chronic bronchitis is worse.

Ciliary beat frequency and physical properties of the mucus layer are two important factors that influence the effectiveness of MCC. In mammals it is known that mucus secretion of epithelial cells is under hormonal and neural control. Neural stimulus starts secretion of mucous and this stimulates ciliary beat mechanically. It has been proven that increases in mucus secretion stimulate ciliary beat but there is no proof about direct control of neural and hormonal
We also investigated the relationship of age and nasal mucociliary clearance (MCC) levels and the relationship was statistically significant. In group II there was a positive correlation between age and preoperative MCC levels and the relationship was statistically significant. Also, in the control group there was a positive correlation between age and nasal MCC levels and the relationship was statistically significant. With these findings, we can say that when age increases also nasal MCC time prolongs.

In a recent study comparing MCC time of different ethnic groups with Chinese people, it was found that nasal MCC time of healthy Chinese people was significantly lower than other ethnic groups. In our study, all of the patients belong to the same ethnic origin.

Today, two groups of methods are used for measuring nasal MCC time. First, one contains a direct method such as a stroboscopic, microcinematographic, or microossilographic method to observe ciliary movements. The second group is based on an indirect method, observing the movement of the mucosal layer from anterior to posterior with various indicators and measuring MCC time. Indirect methods include the saccharine test and Tc 99m studies. In our study, we preferred the saccharine test because it can be obtained more easily and it is more economical than Tc99m. David et al. used saccharine blue to evaluate the MCC time. They judged that if the septoplasty surgery is successfully performed, nasal MCC significantly improves. They also found that there is no significant difference in MCC time between obstructed nasal cavity and the opposite side of the patients with deviated septum. In our study we selected the test side randomly.

Ginzel and Illum evaluated 22 patients with deviated nasal septum as the study group and 60 volunteers as a control group. In this study, it was found that with properly performed septoplasty surgery nasal MCC time significantly decreased. In addition, some animal studies showed that after sinus surgery MCC time also decreases significantly. Shone et al. showed that MCC in nasal cavity improved after septoplasty and endoscopic sinus surgery for nasal polyposis. We found that preoperative and postoperative nasal MCC time in group I (nonsmoking group with septal deviation) was statistically significantly higher than the nasal MCC time of the control group. These findings reveal that nasal obstruction caused by septal deviation alone disturbs nasal MCC, resulting with longer MCC time. MCC time was decreased at the late postoperative period, but did not reach the level of the control group at the 3rd month. These findings correlate with literature studies.

Table 4 Evaluation of preoperative and postoperative mucociliary clearance (MCC) time in group II and the control group

<table>
<thead>
<tr>
<th>MCC</th>
<th>Group II (n = 20)*</th>
<th>Control (n = 20)*</th>
<th>n#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative</td>
<td>26.35 ± 1.78</td>
<td>12.10 ± 1.86</td>
<td>0.001§</td>
</tr>
<tr>
<td>Postoperative</td>
<td>15.80 ± 1.67</td>
<td>12.10 ± 1.86</td>
<td>0.001§</td>
</tr>
</tbody>
</table>

*Values are mean ± SD.
#Student’s t-test.
§p < 0.01.

Table 5 Relationship between age and nasal mucociliary clearance (MCC) times

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Group I</th>
<th>Group II</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preoperative MCC</td>
<td>0.460*</td>
<td>Preoperative MCC</td>
</tr>
<tr>
<td></td>
<td>Postoperative MCC</td>
<td>0.513*</td>
<td>Postoperative MCC</td>
</tr>
</tbody>
</table>

Pearson korelsaçyn test; *p < 0.05; #p < 0.01.

In the study of Stanley et al., 29 smoker and 27 nonsmoker patients’ nasal MCC times were measured by saccharine test and compared. They found that mean nasal MCC time of patients who smoke was 20.8 minutes and mean nasal MCC time of nonsmoking patients was 11.1 minutes and determined that smoking elongates nasal MCC time. They stated that smoking regularly decreases cilia number and changes viscoelastic property of mucus. We also investigated the effects of smoking on MCC in our study. We found that preoperative and postoperative nasal MCC times in patients of group I (nonsmoking group) were statistically significantly lower than in the group II patients (smoking group). This finding obviously shows the negative effect of smoking on nasal MCC time in group II.

Preoperative MCC time of group II was significantly higher than MCC time of the control group. This finding shows that nasal septum deviation with smoking disturbs nasal MCC. After septoplasty surgery in properly selected patients the nasal MCC time decreased at the late postoperative period but still had longer levels than in the control group (at the 3rd month). This also shows the negative effect of smoking on MCC.

James et al. investigated the relationship of age and nasal MCC in a study group aged 11–90 years. They found that as the patient’s age increases the ciliary beat frequency decreases and central microtubulus defects become more obvious. Consequently, they stated that over the age of 40 years nasal MCC time increases. Puchell et al. indicated that mucociliary activity speed in volunteers aged >54 years is lower than younger volunteers because of mucosal atrophy. In the study of Mortensen et al. it was found that there is no statistically significant difference between age and nasal MCC with radioactive studies. In our study in group I there was a positive correlation between age and preoperative MCC time and the relationship was statistically significant. In group II there was a positive correlation between age and preoperative MCC levels and the relationship was statistically significant. Also, in the control group there was a positive correlation between age and nasal MCC levels and the relationship was statistically significant.
In some studies it was determined that nasal MCC was found disturbed at early postoperative periods of septoplasty. If basal cells and basal membrane are intact after surgery, the recovery of nasal mucosa takes 5 days after trauma. If all nasal mucosa layers are damaged mechanically, it takes 1 week for stratified epithelium to regenerate, 3 weeks for formation of new ciliary cells, and at the end of 6th week for total recovery.\textsuperscript{45} For this reason, we waited for full recovery of nasal mucosa and evaluated postoperative nasal MCC times at the 3rd month of control.

CONCLUSION

In this study it was detected that nasal septal deviation and smoking deteriorates nasal MCC time and this result can be seen easily with the saccharine test. The saccharine test is a reliable, easy, and harmless method for measuring nasal MCC time. We showed that properly performed septoplasty surgery decreases nasal MCC time during the late postoperative period, but MCC times are still longer than normal.

REFERENCES


