Effects of Functional Endoscopic Sinus Surgery on Intraocular Pressure

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Objective: To investigate whether functional endoscopic sinus surgery (FESS) for the treatment of chronic rhinosinusitis will induce changes in intraocular pressure (IOP).

Design: Prospective, nonrandomized, preoperative and postoperative study.

Setting: University-affiliated medical center.

Patients: Thirty patients who underwent FESS for chronic rhinosinusitis with or without polyps were prospectively enrolled in this study. Patients with diabetes mellitus, hypertension, glaucoma, previous ocular trauma, history of ocular surgery, and previous use of topical corticosteroid eyedrops were excluded.

Main Outcome Measures: The IOPs were measured by Goldmann tonometry preoperatively, postoperatively on days 1 and 2, and on day 3 after the removal of the nasal packs. Physiological factors such as heart rate and systolic and diastolic blood pressures, which may have some effects on the IOPs, were also recorded.

Results: Ten women and 20 men with a mean age of 39.7 years were enrolled in the study. Twenty-one patients had bilateral chronic rhinosinusitis and 9 patients had unilateral sinus disease. The postoperative ocular discomforts were epiphora (13 of 30 [43%]) and eye pressure (6 of 30 [20%]). The mean±SD IOP of the eye on the side of the operated-on sinus was 13.63±2.33 mm Hg preoperatively. Postoperatively, the mean±SD IOPs were 14.08±2.52 mm Hg on day 1, 13.96±2.64 mm Hg on day 2, and 14.10±2.91 mm Hg on day 3 after removal of the nasal packs (P=.82). The IOP-related factors of heart rate and systolic and diastolic blood pressures also showed no significant difference.

Conclusions: Although FESS may cause variations in the IOP compartment, the changes in IOP are not statistically significant. Therefore, FESS is a safe surgical procedure with respect to ocular physiological function.

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epiphora, headache, nausea, vomiting, or a sensation of pressure in the eyes. Some articles\[9,10\] have described the relationships between conventional sinus surgery and IOP. However, no reports have delineated the possible effects of FESS on ocular physiological function. The purpose of the present study was to evaluate the IOP status before and after FESS for CRS and determine whether the variations might produce adverse effects on ocular physiological function. To the best of our knowledge, the relationship of IOP and FESS on patients with CRS has not been addressed in any published literature.

**METHODS**

**PATIENTS**

Patients with CRS refractory to medical treatment undergoing FESS were prospectively enrolled in the study. The age of the patients ranged from 9 to 71 years (mean, 39.7 years). Nasoendoscopy and preoperative computed tomography of the paranasal sinuses were performed. The diagnosis of CRS was established in compliance with the 1997 American Academy of Otolaryngology–Head and Neck Surgery Rhinosinusitis Task Force definition,\[11\] which describes the typical symptoms that persist for 12 weeks or more. This definition also describes a positive computed tomographic scan that shows opacification or swelling of the ethmoidal and maxillary mucosa and an obstruction of the ostiomeatal complex. The decision to perform surgery was based on symptomatic failure of medical therapy in patients with abnormal nasal endoscopy and computed tomographic findings.

Patients with diabetes mellitus, hypertension, glaucoma, ocular hypertension, previous ocular trauma, history of sinonasal or ocular surgery, and previous use of topical corticosteroid eye drops were excluded. Because the fluctuation of episcleral venous pressure results in changes in IOP, any systemic conditions, such as carotid-cavernous fistula and pulmonary hypertension, that may induce changes in episcleral venous pressure were excluded from this study.

**SURGICAL PROCEDURE**

All FESS procedures were performed by the same surgeon (H.-C.L.) in an inpatient facility. The operation was performed with the patient under general anesthesia with the standard anterior to posterior approach. The following surgical steps were applied: middle meatal antrostomy, anterior ethmoidectomy, sphenoidotomy, and frontal recess surgery. The fingerstall with petroleum jelly gauze was used for nasal packing on operated-on sinus wounds over the middle meatal region. Intranasal packing was removed on the third morning after surgery.

**EVALUATION**

All patients underwent a complete preoperative ophthalmic examination that consisted of best-corrected visual acuity, slit-lamp biomicroscopy, Goldmann applanation tonometry, and dilated fundoscopy as baseline data. The IOP of each eye was measured 3 times, and the mean IOP was calculated. Repeated IOP measurements were performed at the same time on day 1, on day 2, and after removal of the nasal packs on day 3 postoperatively. Physiological factors, such as heart rate and systolic and diastolic blood pressures, were recorded 10 minutes after each IOP measurement. Ocular symptoms were recorded before and after removing the nasal packs.

**STATISTICAL ANALYSIS**

Results were expressed as mean ± SD. The comparisons of IOPs and physiological factors such as heart rate, systolic blood pressure, diastolic blood pressure, and mean blood pressure were generated preoperatively and postoperatively. The comparisons of these values were determined by the Kruskal-Wallis test. Differences were considered to be statistically significant at \( P<.05 \).

**RESULTS**

Thirty patients (20 men and 10 women) participated in the study. Twenty-one patients had bilateral CRS and 9 patients had unilateral CRS. Fifty-one FESS procedures were performed in the paranasal sinuses. None of the 30 patients had postoperative complications. A standard 0 to 10 visual analog scale with an anchor was used to assess the common ocular symptoms such as epiphora and eye pressure postoperatively. Thirteen patients (43%) stated having mild postoperative epiphora, which had a visual analog scale score of 3 or less and disappeared after removal of the nasal packs. The sensation of eye pressure was reported by 6 patients (20%) before the nasal packing was removed and had a visual analog scale score of 4 or less. The changes in the IOPs, heart rate, systolic and diastolic blood pressures, and mean blood pressure were generated preoperatively and postoperatively (Table).

**PREOPERATIVE AND POSTOPERATIVE IOPs**

The mean IOP of the eyes on the side of the operated-on sinus was 13.63 ± 2.33 mm Hg (range, 9.0-18.0 mm Hg) preoperatively, 14.08 ± 2.52 mm Hg (range, 9.0-19.0 mm Hg) on day 1, 13.96 ± 2.64 mm Hg (range, 8.0-20.0 mm Hg) on day 2, and 14.10 ± 2.91 mm Hg (range, 8.0-22.0 mm Hg) on day 3 after removal of the nasal packs. No patient had a postoperative IOP greater than 30 mm Hg. By using the Kruskal-Wallis test, the \( P \) value of .82 was determined while comparing the variations of the IOP at each follow-up time and showed no statistical significance.

Regarding the impact of FESS on the IOP in the eye not operated on, 9 patients had only unilateral CRS and received 1-sided FESS in our series. The average values of IOP in the eye on the side of the sinus not operated on before and after surgery were 14.00 ± 2.40 mm Hg preoperatively, 14.67 ± 2.29 mm Hg on day 1, 14.22 ± 2.39 mm Hg on day 2, and 14.78 ± 2.99 mm Hg on day 3 after removal of the nasal packs, which also were not statistically significant (\( P=.96 \); Kruskal-Wallis test).

**IOP-RELATED FACTORS**

The systolic blood pressures of the patients before and after surgery were 122.6 ± 15.8 mm Hg preoperatively, 130.5 ± 16.4 mm Hg on day 1, 131.8 ± 18.3 mm Hg on day 2, and 130.7 ± 13.3 mm Hg on day 3 after removal of the nasal packs (\( P=.12 \); Kruskal-Wallis test). The diastolic blood pressures of the patients before and after surgery were 72.4 ± 12.6 mm Hg preoperatively,
blood flow is compromised, normally accompanied by a normal, no immediate treatment is necessary. If retinal blood flow is more than 40 mm Hg, a poor vision result may ensue. At this stage, fundus examination is used to assess the eye can be observed, and in cases in which the IOP is less than 30 mm Hg, general, in cases in which the IOP is less than 30 mm Hg, the eyeball, orbit, and parts of the sinonasal region have the same origin of vascular supply. The ophthalmic artery, long posterior ciliary arteries, and short posterior ciliary arteries derive from the ophthalmic artery, and the anterior and posterior ethmoidal arteries are also derived from the ophthalmic artery, and the anterior and posterior ethmoidal veins drain into the superior ophthalmic vein. The vascular supplies of the sinuses are partial from the anterior and posterior ethmoidal arteries. The anterior and posterior ethmoidal arteries are also derived from the ophthalmic artery, and the anterior and posterior ethmoidal veins drain into the superior ophthalmic vein. Because the eyeball, the orbit, and some of the sinonasal region have the same origin of vascular supply, and because the post-FESS symptoms of epiphora and eye pressure were similar to the symptoms of increased IOPs, we wanted to elucidate whether FESS would result in a significant change in the IOP before and after surgery. In this article, we conducted, to our knowledge, the first prospective study to investigate the pre-

### Table. Changes in IOP and IOP-Related Physiological Characteristics at Each Follow-up Time

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Before Operation</th>
<th>Postoperative Day 1</th>
<th>Postoperative Day 2</th>
<th>Postoperative Day 3</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operated-on side IOP, mm Hg</td>
<td>13.63 ± 2.33 (12.97 to 14.28)</td>
<td>14.08 ± 2.52 (13.37 to 14.79)</td>
<td>13.96 ± 2.64 (12.22 to 14.70)</td>
<td>14.10 ± 2.91 (13.28 to 14.91)</td>
<td>.82</td>
</tr>
<tr>
<td>Change in IOP, mm Hg</td>
<td>...</td>
<td>0.45 ± 1.78 (−0.05 to 0.95)</td>
<td>0.33 ± 2.43 (−0.35 to 1.02)</td>
<td>0.47 ± 2.39 (−0.20 to 1.14)</td>
<td></td>
</tr>
<tr>
<td>Systolic blood pressure, mm Hg</td>
<td>122.6 ± 15.8</td>
<td>130.5 ± 16.4</td>
<td>131.8 ± 18.3</td>
<td>130.7 ± 13.3</td>
<td>.12</td>
</tr>
<tr>
<td>Diastolic blood pressure, mm Hg</td>
<td>72.4 ± 12.6</td>
<td>77.1 ± 9.3</td>
<td>77.3 ± 12.3</td>
<td>77.1 ± 10.7</td>
<td>.37</td>
</tr>
<tr>
<td>Mean blood pressure, mm Hg</td>
<td>89.2 ± 12.8</td>
<td>95.0 ± 11.1</td>
<td>95.5 ± 12.3</td>
<td>94.9 ± 9.7</td>
<td>.18</td>
</tr>
<tr>
<td>Heart rate, beats/min</td>
<td>76.0 ± 10.0</td>
<td>76.6 ± 9.5</td>
<td>77.1 ± 9.1</td>
<td>75.7 ± 11.8</td>
<td>.93</td>
</tr>
</tbody>
</table>

Abbreviations: IOP, intraocular pressure; ellipses, not applicable.

Data are expressed as mean ± SD (95% confidence interval).

By Kruskal-Wallis test.

Data are the difference in IOP between preoperation and day 1, preoperation and day 2, and preoperation and day 3 by Wilcoxon signed rank test for paired data (P = .09, P = .63, and P = .24, respectively).

Functional endoscopic sinus surgery is one of the most common surgical procedures performed by otolaryngologists. Potential risks exist in the surrounding structures during sinus surgery. The incidence of serious complications of endoscopic sinus surgery has been reported as 0.5% or less. The complications include cerebrospinal fluid leak, nasolacrimal duct injury, carotid injury, and orbital damage. The clinical sequel of orbital injuries can range from eye pressure, pain, retrobulbar hemorrhage, and compromised extraocular muscle movement with sequential binocular diplopia to blindness. Graham and Nerad further suggested the management of orbital complications in endoscopic sinus surgery. In general, in cases in which the IOP is less than 30 mm Hg, the eye can be observed, and in cases in which the IOP is more than 40 mm Hg, a poor vision result may ensue. At this stage, fundus examination is used to assess the blood flow to the optic nerve. If the retinal blood flow is normal, no immediate treatment is necessary. If retinal blood flow is compromised, normally accompanied by a high IOP of greater than 40 mm Hg, an immediate canthotomy with upper and lower cantholysis should be performed.

Excessive gauze packing and overinflated antral balloons of the Foley type, after the Caldwell-Luc operation has been performed to splint the orbital floor fragments, has been reported to induce hypertropia and compression of the central retinal artery. In 1974, Gelman et al reported a case of acute ocular hypertension following the use of an antral balloon after repairing fractures on the floor of the orbit via a Caldwell-Luc antrostomy. Papangelou and Christidis further studied whether there would be some effects on the IOP in patients who underwent a Caldwell-Luc operation for chronic sinusitis or antral polyps. They found that some changes of IOP occurred whether or not the maxillary sinus walls were denuded of mucous membrane.

Anatomically, the eyes and paranasal sinuses are neighboring structures. The eyeball, orbit, and parts of the sinonasal areas share the same vascular supply from the ophthalmic artery. The central retinal artery, long posterior ciliary arteries, and short posterior ciliary arteries emerge from the ophthalmic artery and supply the orbit and ocular structures. The venous drainage of the orbit and ocular structures are via the central retinal vein and the vortex vein; the former drains into the superior ophthalmic vein and the latter drains into the inferior ophthalmic vein. The vascular supplies of the sinuses are partial from the posterior ethmoidal arteries. The anterior and posterior ethmoidal arteries are also derived from the ophthalmic artery, and the anterior and posterior ethmoidal veins drain into the superior ophthalmic vein. Because the eyeball, the orbit, and some of the sinonasal region have the same origin of vascular supply, and because the post-FESS symptoms of epiphora and eye pressure were similar to the symptoms of increased IOPs, we wanted to elucidate whether FESS would result in a significant change in the IOP before and after surgery. In this article, we conducted, to our knowledge, the first prospective study to investigate the pre-
operative and postoperative changes of the IOPs in patients receiving FESS for treatment of their sinus diseases.

The origin of IOP is determined by a balance between the formation of the aqueous humor and its excretion. The aqueous humor drains the episcleral veins. Episcleral venous pressure is relatively stable, except when alterations in body position and certain surgical procedures and diseases of the orbit, head, and neck obstruct return of venous blood to the heart or shunt blood from the arterial to the venous system. When the episcleral venous pressure is elevated, it blocks the optimal exit for the aqueous humor and contributes to a rise in the IOP. Equilibrium of the IOP is essential for normal eye function. A low IOP can produce cataracts, choroid detachment, and papillary edema, whereas a high IOP can cause corneal edema, paralysis of the pupillary sphincter, atrophy of the iris, cataract, and optic nerve atrophy. The IOP can be altered by many factors, including age, sex, and race; physiological factors, such as time of day, heartbeat, respiration, exercise, fluid intake, position, and corneal thickness; clinical factors, such as systemic medications for control of blood pressure, systemic or topical corticosteroids, intraocular surgery, increased episcleral venous pressure, increased resistance of systemic venous return, and ocular trauma and inflammation; and other factors, such as intraobserver or interobserver variability, external pressure on the globe, breath holding or Valsalva maneuvers, tight collars, or inaccurately calibrated tonometer.

The IOP can be measured clinically by various types of tonometers, including the Goldmann applanation tonometer, noncontact tonometer, and Tonopen. The Goldmann applanation tonometer measures the force necessary to flatten an area of the cornea with a 3.06-mm diameter. A slit-image prism allows the examiner to determine the flattened area with great accuracy. Applanation measurements are safe, easy to perform, and relatively accurate in most clinical situations. Noncontact (air-puff) tonometers measure IOP without touching the eye by measuring the time necessary for a given force of air to flatten a given area of the cornea. They are often used in large-scale glaucoma-screening programs or by nonmedical health care professionals. Tonopen, which applanates a very small area of the cornea, is particularly useful in the presence of corneal scar or edema. Of the currently available devices, the Goldmann applanation tonometer is the most valid and reliable. Therefore, we used the Goldmann applanation tonometer to measure the alterations of IOP at different times.

The mean IOP is approximately 16 mm Hg, with an SD of 3 mm Hg. However, no clear line exists between safe and unsafe IOPs. In healthy individuals the IOP varies from 2 to 6 mm Hg during a 24-hour period because aqueous humor production changes. Thus, we reasonably measured IOP data in all of our patients at the same time preoperatively and postoperatively to avoid the biases of IOP fluctuations before and after FESS. Blood pressure and heart rate are factors that could affect the IOP. Mitchell et al16 showed that a 3-mm Hg linear IOP increase over the clinical spectrum of blood pressure level was evident. We recorded the variations of blood pressure and heart rate 10 minutes after IOP measurements to avoid the physiological effects on IOP during the study period. At each follow-up time before and after FESS, none of the IOP-related physiological factors showed a statistically significant change.

Injury to the lacrimal drainage system with resultant epiphora is a complication of FESS. Thirteen patients (43%) experienced epiphora postoperatively, but the symptom disappeared after removal of the nasal packs. Thus, FESS is unlikely to injure the lacrimal system in our patients. Epiphora and eye pressure might be due to local edematous change or postoperative pain over the sinonasal areas, not actually in the orbits or eyeballs.

In the present study, patients with preexisting glaucoma, a major disorder of persistently increased IOP, were excluded. Herein, the variations of the IOP before and after FESS showed no significant difference in patients without glaucoma. Increased IOP may result in further optic nerve damage due to vascular compromise in patients with glaucoma. Therefore, further investigation of IOP changes before and after FESS in patients with glaucoma and refractory CRS may be warranted.

In conclusion, this study demonstrates that FESS for the treatment of CRS causes no significant variations in the IOP in nonglaucomatous patients before and after the surgery. Therefore, FESS is a safe surgical procedure with respect to ocular physiological function.

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