PRESUMED SINUS-RELATED STRABISMUS

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ABSTRACT

Purpose: To determine whether sinus disease may cause acquired strabismus.

Methods: Patients with idiopathic acquired (nonaccommodative) esotropia and/or hypotropia were questioned in detail about possible contributing factors (trauma; family history of strabismus; thyroid, neurologic, or rheumatologic disorders). Acute versus chronic onset was ascertained. Those without obvious cause of strabismus were investigated for possible sinus disease with sinus computed tomographic scan and otolaryngologic consultation.

Results: Over a period of 5 years, 59 patients were identified with sinus disease that correlated to their strabismus pattern(s). Twenty-three had "possible" sinus-related strabismus. They had sinus findings that correlated with the strabismus pattern (eg, hypotropia and adjacent maxillary sinus disease). Twenty-six had "likely" sinus-related strabismus. These patients had additional features, such as their own recognition that strabismus worsened along with sinus symptoms, or unusually severe sinus disease. Ten were diagnosed with "very likely" sinus-related strabismus. They had strong correlation between treatment of sinus disease and strabismus improvement. Eighteen patients required sinus surgery owing to failure of medical control. Age at onset of strabismus ranged from 6 months to 81 years. Forty patients required strabismus surgery. All had restriction of motility on forced duction testing under anesthesia. Control of sinus disease combined with range-of-motion eye exercise improved symptoms in 19 who did not require strabismus surgery.

Conclusions: Occult sinus disease may cause acquired strabismus. Perhaps sinusitis leads to inflammation and secondary contracture in adjacent extraocular muscles. Although difficult to prove owing to the high frequencies of both strabismus and sinus disease, the association between the two may prove significant to strabismus treatment and long-term control.

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INTRODUCTION

Despite complete evaluation of patients in a strabismus practice, there exists a subset of cases in which etiology remains unclear. This group includes acquired nonaccommodative esotropia in children and adults, gradually progressive vertical strabismus, and combinations of the two. These patients may have evidence of muscle fibrosis, but workups for thyroid ophthalmopathy, rheumatologic disorders, or other predisposing systemic diseases are negative.

It is the clinical impression of this author (I.H.L.) that the inferior and medial recti are the extraocular muscles most prone to develop fibrosis, excepting cases with prior muscle surgery or trauma. This led to the postulate that fibrosis of the medial and inferior recti could be related to their proximity to the adjacent ethmoid and maxillary sinuses, respectively.

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METHODS

Patients with atypical acquired strabismus (nonaccommodative acquired esotropia, gradually progressive vertical strabismus) suggesting fibrosis of the medial and/or inferior rectus muscles were evaluated for sinus disease. Others with fibrotic muscles and/or thickened, fibrotic orbital fat pad in the inferior fornix observed at surgery also underwent sinus investigation.

Patients were treated in several locations but, when possible, were referred to the same otolaryngologist (J.F.S.). For the patients seen in this center, the otolaryngology *Clinical Indicators Compendium* for rhinosinusitis was used to evaluate symptomatology.[1] Major clinical indicators were facial pain, facial congestion, nasal obstruction, nasal discharge, and unpleasant odor. Minor clinical indicators were headache, fever, bad breath, fatigue, dental pain, cough, and ear pain. Each indicator was given

a scale of 0 to 10, for a maximum total score of 120. Of the 59 cases in this study, 26 were evaluated by J.F.S. These 26 cases were analyzed separately to grossly estimate incidence of sinus disease in acquired strabismus.

In other locations, patients were referred to another otolaryngologist or pediatrician for sinus evaluation and treatment. Sometimes, to expedite evaluation, sinus computed tomographic (CT) scans were obtained first, to rule out sinusitis before referring the patient.

RESULTS

Fifty-nine patients were identified with strabismus and sinus disease. They were subdivided into three groups based upon the strength of the association between the two conditions in each patient. "Very likely" sinus-related strabismus was defined as those patients whose alignment improved with sinus disease treatment. Ten patients fell into this category. "Likely" sinus-related strabismus was defined as strabismus with unusually severe adjacent sinus involvement, or moderate sinus disease plus additional suggestive features, such as the patient's realization that strabismus symptoms worsened simultaneously with upper respiratory tract illness. This group included 26 patients. "Possible" sinus-related strabismus was the finding of sinus disease on CT scan without other supporting evidence. Twenty-three patients were classified in the "possible" group. Age at onset ranged from 6 months to 81 years, with a mean of 34 years.

Most of the 59 patients had resolution of sinus disease with medical control, but sinus surgery was required in 18.

Of 26 strabismus patients seen by J.F.S. for otolaryngologic evaluation, 24 (92.3%) had positive findings of sinus disease on limited paranasal sinus CT scan. Fifteen (57.6%) had active sinusitis, and nine (34.6%) had significant sinus anatomic abnormalities. For major clinical indicators, 15 (57.6%) had mild symptoms of sinus disease, 9 (34.6%) had moderate symptoms, and 2 (7.6%) had severe symptoms. Six cases (23%) had a total score of ≤10 out of 120, which is classified as no clinical history of sinusitis.

Of the 59 cases in this series, 40 required strabismus surgery. All those who underwent strabismus repair had positive forced duction testing suggesting fibrosis of the extraocular muscles. The most commonly involved muscles were the inferior and medial recti. The resistance to forced duction by the oblique muscles was assessed in 21 patients by the measurement of passive resistance to intorsion and extorsion of the eye. Normal was defined as 60 degrees or more torsion before resistance was met. The exaggerated forced duction test of the obliques[2] was also used to confirm oblique tightness. Tight superior obliques were found in 16 patients, and tight inferior obliques were detected in 13. Resistance to depression or adduction, which would suggest fibrosis of the superior or lateral recti, was not detected. Eleven had resolution of symptoms with sinus treatment and motility exercise alone, and eight had persistent diplopia controlled by prism without requiring strabismus surgery.

Thirty-seven patients had acquired esotropia. Twelve of these had been previously diagnosed with sixth cranial nerve palsy. Force generation testing confirmed normal lateral rectus strength when the diagnosis was in doubt. Twenty-five had comitant esotropia, and 12 had a high accommodative-convergence relationship. Intermittent esotropia was present in 16, and they underwent preoperative prism adaptation to uncover their full deviations.

Nineteen patients had vertical strabismus with measurements suggesting fourth cranial nerve palsy. The diagnostic clue to fibrosis of the contralateral inferior rectus was usually mild extorsion of the hypotropic eye as opposed to the extorsion of the hyperdeviating eye expected in fourth cranial nerve palsy. At surgery, these patients had tightness of the involved inferior rectus and no laxity of the superior obliques by forced duction testing. They each had a thickened, fibrotic orbital fat pad in the inferior fornix (Figure 1). Most actually had tightness of the superior obliques on forced duction testing.

One patient had severe upgaze restriction with ptosis due to ipsilateral maxillary sinus infection, which mimicked partial third cranial nerve palsy.

Seven patients developed strabismus recurrence despite good alignment after initial strabismus repair. The unexplained recurrences led to sinus investigations in this group.

Stereopsis testing was recorded in the 52 patients who were old enough to perform the test. After alignment was restored, only one showed no stereopsis to the near Titmus test. This patient had more than 30 years of

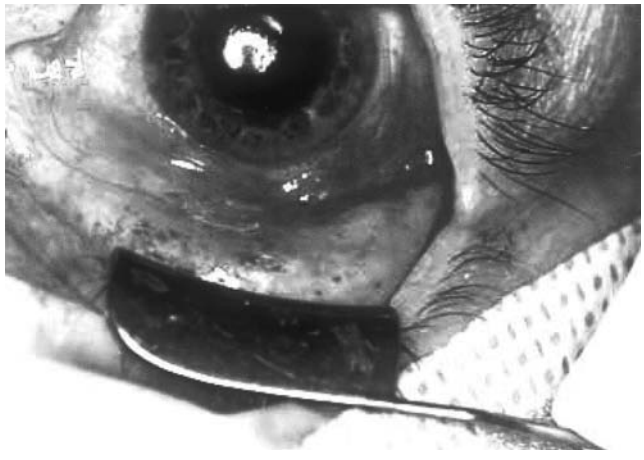

FIGURE 1
Inferior fornix fibrosis seen during surgery for fibrotic inferior rectus in a patient with acquired vertical strabismus, presumably due to chronic sinus disease

constant esotropia. Fifteen patients had 40 seconds(s) of stereopsis or better, 17 had 50 to 80 seconds, 10 had 100 to 200 seconds, and 9 had 400 to 800 seconds.

A mother of a child with recurrent esotropia volunteered that she can now predict a recurrence of sinusitis when the child's esotropia worsens. His otolaryngologist has confirmed each episode. Prompt antibiotics then improve his alignment control. One patient had amblyopia in an eye, which had nonetheless been aligned. She developed hypotropia of that eye without diplopia. She had complete opacification of the ipsilateral maxillary sinus.

Four additional patients were not included in this series because they had preexisting strabismus due to nonsinus etiology. They all had undergone previous successful strabismus repairs, but then developed strabismus recurrences following sinusitis. All had known orbital bony wall defects. Two had thyroid ophthalmopathy with previous orbital decompressions, and two had prior orbital trauma. The thyroid patients responded to prompt antibiotics plus motility exercise, and the post-traumatic patients needed small additional strabismus repairs.

Case Reports

Case 1. Pseudo Sixth Nerve Palsy

A 5-year-old boy was brought for a sixth opinion regarding esotropia. He had developed acute esotropia [LE(T) = 30] at age 3 coincident with otitis media. A diagnosis of acute viral left sixth cranial nerve palsy was made at that time. Computed tomographic scan of the head was normal and esotropia persisted. He underwent botulinum toxin injection to the left medial rectus 3 months later, with no effect. Glasses for a +2.00 hyperopia, with +2.50 add, were prescribed. Seven months after onset of acute esotropia, he underwent recession of the left medial rectus, which reduced the esodeviation in the glasses, but uncorrected esotropia of 25 PD persisted.

The patient's parents were not accepting of a diagnosis of accommodative esotropia, because his identical twin brother had no strabismus and there was no family history of strabismus or glasses wear (Figure 2).

By age 5, at our visit, he had accommodative esotropia with a high accommodation convergence/accommodation (AC/A) relationship, which was controlled with full cycloplegic correction with bifocals except for manifest esotropia of 14 in downgaze. Version testing showed full abduction in both eyes and apparent superior oblique underaction. Visual acuity was 20/25 in each eye, stereopsis was 100 seconds of arc, and fundi were mildly extorted. He was healthy, other than occasional nasal congestion. Computed tomography of the sinuses showed severe pansinusitis, including the sphenoids (Figure 3). The sinus disease failed to respond to medical treatment, and he underwent sinus surgery. V-pattern esotropia persisted, and he then underwent bilateral medial rectus recession together with multiple myotomy lengthening procedures to the inferior recti. Medial and inferior recti were found to be stiff and fibrotic, and there was no laxity of the superior obliques to forced duction. One year postoperatively, V-pattern is resolved, as is the high AC/A relationship. Cycloplegic

FIGURE 2

Case 1. Patient on right, identical twin on left. Twin did not develop manifest esotropia, possibly due to regular treatment of his frequent sinus infections. Patient's sinus disease was minimally symptomatic and not previously treated.

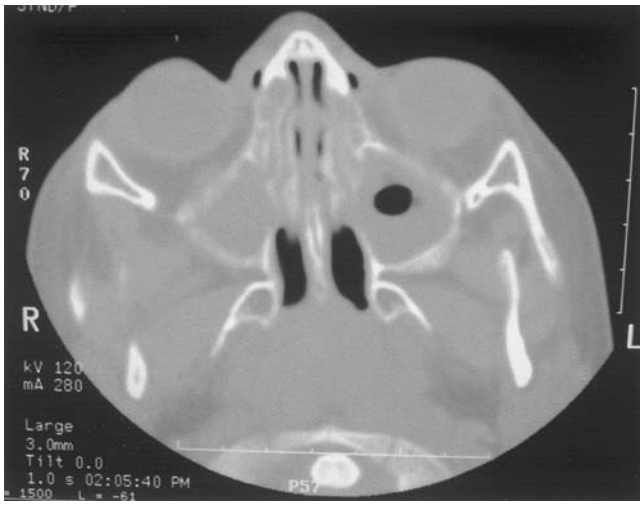

FIGURE 3

Case 1. Computed tomographic scan showing pansinusitis.

spherical equivalent is +3.25, but he can now maintain alignment with +2.25 and no bifocals. Stereopsis is 40 seconds.

Both parents and his identical brother were tested for stereopsis, which was 40 seconds in each. The brother underwent complete examination, which showed esophoria of 4 PD and hyperopia of +1.25 diopters but was otherwise normal. The boy had had a long history of sinus disease, allergies, and asthma, which had been regularly treated. Perhaps early sinus treatment protected him from esotropia.

Case2. Pseudo Sixth Nerve Palsy

A 15-year-old girl presented with a 1-month history of diplopia. She had already undergone extensive ophthalmologic and neurologic evaluations at a major university medical center for idiopathic esotropia, which was diagnosed as sixth cranial nerve palsy. Past medical history was negative.

She had esotropia of 14 PD, greater on right gaze, decreased on left gaze. There was minimal limitation of abduction in both eyes and mild elevation limitation in the left eye. Examination was otherwise normal. Magnetic resonance imaging scan of the head, which had already been performed at the hospital, was neurologically normal, but showed incidental maxillary and ethmoid sinus disease. After several days of an oral antibiotic and decongestant, diplopia resolved. Several months later a follow-up motility examination was normal.

Case 3. Pseudo Fourth Nerve Palsy

A 43-year-old woman reported having vertical diplopia since childhood. It was improved with left head tilt and had become increasingly symptomatic with age. She had right hypertropia of 12 PD, increasing to 30 PD on left gaze, 40 PD on right gaze, and 18 PD on right head tilt. There was 3+ overaction of the right inferior oblique, 2– underaction of the right superior oblique, and mild elevation deficit of the left eye. Subjective torsion measurement was 7 degrees excyclotorsion OD, 5 degrees extorsion OS. She was diagnosed with right superior oblique palsy and underwent 12-mm recession of the right inferior oblique and 4-mm advancement of the superior oblique under local anesthesia. The use of local anesthesia prevented adequate forced duction testing.

Postoperatively, alignment measured orthotropic, but the patient complained of diplopia. Two months later she had a left hypertropia of 4, increasing to 14 on downgaze. She had 7 degrees of extorsion OS. Diagnosis of unmasked left superior oblique palsy was made, and reoperation was undertaken, this time under general anesthesia. Forced duction test surprisingly showed marked fibrosis of both inferior recti and tightness of the superior obliques and left medial rectus. Both inferior recti were recessed with nonabsorbable suture, the left 4 mm, and the right 5 mm. The right inferior oblique was also maximally recessed posteriorly. The inferior recti were found to be fibrosed to surrounding orbital fat, which was also fibrosed and thickened, creating a bulge in the inferior fornix.

Postoperatively, she was again orthotropic, but uncomfortable, and with vague symptoms of blurred vision, although vision measured 20/20 OD, 20/15 OS. Two months later, left hypertropia of 8 PD had recurred, and she underwent further recession of the right inferior rectus, and recession of the right superior oblique to its original insertion. Again, she was orthotropic for 2 months before the left hypertropia recurred. The right eye showed restriction to upgaze. There was no limitation to downgaze OS.

Because of presumably increasing inferior rectus fibrosis, the patient was referred for otolaryngologic examination and sinus CT scan. Otolaryngologic history was normal with a total score of 2/120. Her otolaryngologic examination was normal, as was her nasal endoscopy. CT scan showed paranasal sinus disease in both maxillary sinuses, both ethmoids, and the left frontal, rating 4 and 5 on the Lund-Kennedy staging system.[3] Two months of continuous medical treatment failed to clear the sinusitis, and she underwent fiberoptic endoscopic sinus surgery, with intraoperative findings of ethmoid polyposis and fungal-appearing mucus. After sinus surgery, she felt marked improvement in her discomfort and well-being and resolution of "blurred vision," but diplopia persisted owing to left hypertropia of 10 PD. She underwent a fourth strabismus procedure with 2-mm additional recession of the right inferior rectus and inferior conjunctival recession. She has maintained orthotropia with complete resolution of all visual symptoms for 4 years. Her sinus disease is controlled with topical corticosteroid spray.

Case 4. Pseudo High AC/A Ratio

A pediatrician brought her 6-year-old daughter for examination because the child's teacher had noticed esotropia. The child's mother then began to notice intermittent esotropia when she was tired. Alignment was normal at distance in all directions of gaze, but intermittent esotropia of 12 PD was seen at near. Versions showed mild underaction of the inferior obliques, and mild elevation deficiency in one eye. Her mother was counseled about possible sinus infection but declined to investigate the sinuses because of the child's lack of sinus symptoms.

Two months later, the child was hospitalized for treatment of bacterial meningitis, felt to be due to spread from bilateral maxillary sinusitis. She was successfully treated medically. Esotropia did not recur.

DISCUSSIONS

Isolated strabismus cases due to acute sinusitis have been reported in the literature. Two cases of acute-onset Brown's syndrome occurred due to pansinusitis,[4] and superior oblique palsy attributed to sinusitis[5] has also been described.

Ophthalmic complications of adjacent sinusitis have long been known. These include cellulitis,[6-9] orbital abscess,[7-9] orbital myositis,[10] cavernous sinus thrombosis,[7-9] and blindness.[7-9] Strabismus due to sinusitis was usually attributed to cranial nerve palsies owing to cavernous sinus involvement.[10-12] Most reported cases of ophthalmic complications of sinusitis were related to symptomatic, acute, fulminant sinus disease. Vertical diplopia due to chronic asymptomatic sinusitis has been described due to orbital floor collapse, which leads to enophthalmos and hypoglobus.[13]

Sinus lesions such as mucoceles,[14,15] osteomas,[16] and malignancies[14] are known to cause diplopia due to direct orbital extension. Damage to extraocular muscles with secondary strabismus is a reported complication of sinus surgery.[17-19]

The strabismus cases in this study were different from previously reported cases in that most of the patients were unaware of sinus disease. Few had clinical evidence of sinus disease, although in retrospect, several reported improved health and decreased facial pain after clearing of sinusitis. One mother reported resolution of her son's chronic rhinorrhea, but before treatment, neither she nor his pediatrician had been concerned about his mild symptoms. Office otolaryngologic examination was not adequate to diagnose sinusitis in this group. Sinus CT scans were required to diagnose and monitor sinusitis.

In a population-based study of childhood esotropia, idiopathic acquired nonaccommodative esotropia was reported in 10.4%.[20] During data analysis of a large series of accommodative esotropia, a number of cases did not fit into the accepted definitions of congenital or accommodative esotropia.[21] These may also represent acquired nonaccommodative esotropia. The children with sinus-related esotropia in this series may be similar to the same subsets of childhood esotropia as the other studies.

Superior oblique palsy appearing in late childhood without neurologic abnormality or trauma was felt to be due to decompensation of a previously asymptomatic but congenital defect.[22] Nineteen of the cases in this study could have been classified as fourth cranial nerve palsy based upon alignment testing. The findings of contralateral inferior rectus fibrosis described above differentiated these cases from true fourth cranial nerve palsy.

Gradual-onset adult strabismus is also often attributed to decompensation of congenital strabismus,[22] unless neurologic or myopathic etiology is diagnosed. Some of the patients in this series had been wearing gradually increasing spectacle-mounted prisms for many years, and one had noticed the temporal coincidence between his yearly sinus infection and the need for a yearly increase in prism strength.

Some of the patients in this study had acute or subacute onset of diplopia. Cranial nerve palsy was the clinical diagnosis until imaging disclosed sinusitis (Figure 4). Force generation testing of the suspected palsied muscle was a useful diagnostic test in the older children and adults. Motility limitation was less marked in these cases than would be expected in cranial nerve palsy, and saccades were not slowed.

Since the advent of broad-spectrum antibiotics, the serious complications of acute sinusitis of the past have become rare.[7,9] The serious ophthalmic complications of sinusitis that appeared in the early literature included blindness and severe palsy of multiple cranial nerves. These are not found in the modern literature but were familiar to clinicians prior to 1950.[12] Sinus disease itself remains common, however. One study showed positive CT scan findings of sinus disease in 15% of asymptomatic individuals.[23] Another recent study found mucosal thickening in 17% of a control group of CT scans for unspecified orbital disease, but only 2% had radiologically significant sinus disease.[3] A chronic, smoldering sinusitis could be predicted to cause a milder inflammation with secondary fibrosis of adjacent orbital tissues and extraocular muscles rather than palsy of the cranial nerves. A 1950 study ascribed strabismus to sinusitis in 10 cases.[12] Diplopia was attributed to cranial nerve palsy in all 10, and most had severe acute sinusitis with multiple symptoms. Sinus treatment improved motility without strabis-

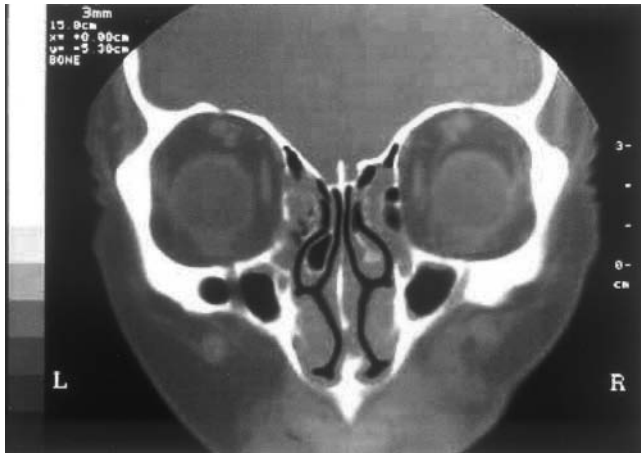

FIGURE 4
Magnetic resonance imaging scan of a 73-year-old man with acute onset of esotropia, showing bilateral ethmoid sinusitis. Esotropia fully resolved after 1 month of antibiotic treatment.

mus surgery in each patient. Several, however, had subacute presentations with milder strabismus and sinus symptoms, consistent with the cases in this series.

It is possible that some of the patients in this series may have experienced a component of cranial nerve palsy at some point, although none had muscle weakness at the time of treatment. Otitis media and sinusitis may occur simultaneously, and a sixth cranial nerve palsy due to mastoiditis[14] must also be considered in a case of acute acquired esotropia. The incomitance of acute cranial nerve palsy was not prominent in this series, however.

The medial wall of the orbit contains three vertical fissures: the lacrimomallary, the lacrimoethmoidal, and the sphenoethmoidal foramina. Vessels and nerves travel through these foramina. There may also be congenital dehiscences in the medial orbital wall. These structures may allow transmission of inflammation or infection from the ethmoidal sinuses to the orbit.[7] The orbital floor is formed by the maxillary sinus roof, which is a thin bone, through which travels the infraorbital nerve. The inferior orbital wall may be dehiscent, with no bony covering. These weaknesses may allow transmission of inflammation from the maxillary sinuses into the orbit. Chronic sinusitis itself may cause erosion of orbital bone. Orbital cellulitis and orbital abscesses are well-known complications of sinusitis. It is logical to assume that subclinical orbital infection or inflammation could exist without progressing to manifest cellulitis or orbital abscess.

Proving the link between the sinus disease and strabismus may be impossible in this heterogeneous group of patients. Both disorders are chronic and common. There are many individuals with recurrent sinusitis who never develop strabismus and many strabismus patients who have no sinusitis or unrelated sinusitis. The patients reported here had atypical strabismus, which responded poorly to standard treatment until sinusitis was controlled. Some cases resolved with sinus treatment alone, and many had unusually severe sinus inflammation by radiologic examination and at surgery. Although incidence figures are not available in this study, it is the authors' impressions that the incidence of positive CT scans exceeded 50%. The strabismus patients seen by the J.F.S. center had a 90% incidence of sinus abnormalities by CT scan. This series had many with complete pansinusitis or complete obliteration of one or more sinuses. That high degree of severity was previously reported in only 2% of asymptomatic controls with orbital CT scans.[3]

A normal sinus CT scan may not prove that earlier sinusitis did not contribute to strabismus. Recurrent bouts of subacute sinusitis could cause progressive extraocular muscle fibrosis, but then not show up on scans between episodes.

Patients with amblyopia or decreased fusion due to prior strabismus could be predisposed to worsening or recurrence of strabismus if the extraocular muscles become inflamed by sinusitis. They often have less fusional reserve than normal and may be less able to adapt to changes in muscle tension.

When the strabismus patient presents with an atypical history and examination, which could represent extraocular muscle fibrosis, it is worthwhile to investigate for possible sinus disease. Sinus treatment may improve alignment if the strabismus is of recent onset. Sinus disease management may also reduce the risk of strabismus recurrence after successful surgery. Regular stretching of the extraocular muscles to prevent shortening seemed to assist some patients when they began to notice recurrent diplopia. If unexpected fibrosis of the extraocular muscles is detected at surgery, sinus evaluation may still be of value to prevent strabismus recurrence.

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DISCUSSION

Dr David R. Stager, Sr. Atypical or unexplained acquired strabismus poses a challenge to the strabismus specialist and it is therefore commendable that the authors have undertaken this attempt to relate such cases with possible sinus-related abnormalities. However, as a survey supported by the American Academy of Otolaryngology has found, 42 percent of people surveyed reported having at least one sinus infection in the last 12 months. It has been estimated that 37 million people in this country have sinus disease. This certainly creates a distinct possibility of a causal relationship between strabismus and sinus disease. From an epidemiologic standpoint, it would be important to identify the incidence of strabismus problems in patients who have sinus disease. How many patients in this study with acquired strabismus have a normal CT scan (and could serve as a control group)? The answers to these questions would help us determine whether there is a cause-and-effect relationship between sinus disease and atypical acquired strabismus or whether this relationship is coincidental. I found some of the clinical descriptions confusing. Do the measurements change as the fibrotic muscle is placed on stretch? Would that help distinguish the 25 patients with comitant esotropia or the 19 patients with suspected fourth nerve palsy versus fibrosis of the inferior rectus muscle? How does muscle fibrosis cause a high AC/A ratio?

Secondly, is there a way of documenting an inflammatory basis of eye muscle involvement such as high resolution MRI or histopathology of adjacent tissue or experiments with an animal model? Could one demonstrate an improvement of length-tension curves of the inflamed and fibrotic muscles before and after treatment of sinus disease?

Dr Ludwig has alerted us to a potential cause of acquired incomitant strabismus. Historically, she has proven herself to be a keen observer. If further investigation confirms the association of sinus disease and strabismus, we will owe her our gratitude. This will provide us with a non-surgical treatment that may be more effective than what is currently available. However, a great deal of investigative work needs to be done. What level of sinus disease can cause strabismus? What types of strabismus may be due to this syndrome, as opposed to a coincidental relationship?

Although this concept is in its infancy, and quite tenuous, Dr Ludwig's paper is innovative and thought provoking. She does think "outside the box," a talent that often leads to great progress.

Dr Malcolm L. Mazow. You might try to determine the frequency or incidence of strabismus that occurs after significant orbital cellulitis. In my practice, it does not seem to be very common.

Dr Allan J. Flach. You seem to have converted a surgical disease into a medical disease and should be congratulated. In my adult practice, my most troublesome patients are thyroid patients. Could you comment about what you think might occur in thyroid patients when they have an orbital decompression? Does the decompression do something to the sinus and might it have some impact on your study? I do not see anything wrong with a therapeutic trial of antibiotics in your patients with this condition since it might help someone avoid surgery.

Dr Robert Ritch. I came back from Germany in January with bad sinusitis, losing all sense of olfaction and taste. A couple of days after that, I developed diplopia, which turned out to be a comitant partial sixth nerve palsy. I was scheduled to get an MRI when, as Chair of this AOS program, your abstract came in the mail. A couple of days later, I was in a conference call with Dr Marilyn Miller and she mentioned she had similar cases. I performed a literature search but really could not find very much outside of severe complications, like orbital cellulitis and orbital pseudotumor. I urge you to continue to delve

further into this problem and consider reporting your additional findings.

Dr Alan H. Friedman. Did any of the pre-op CT or MRI scans show any abnormalities in the extraocular muscles? In pseudotumor and in thyroid ophthalmopathy, we do see abnormalities in the muscles. Is this a time measure saccades or even EMG's of suspected abnormal ocular muscles? Was ocular pathology performed on any of your cases?

Dr John T. Flynn. What muscle-stretching exercises should be performed in this context?

Dr George B. Bartley. The frequency in this cohort of sinus surgeries seems pretty high. Did the culture results from these cases differ from what is typically seen in age-related controls that have sinusitis but yet do not require surgery?

Dr Edward L. Raab. Many of us in pediatric ophthalmology see children, especially in the hospital, who might have orbital cellulitis and actually turn out to have periorbital cellulitis. In most children old enough to have sinuses, they have a lot of evidence of sinusitis, but hardly ever any restriction to motility. Any reason to think there's leakage into the orbit? Where there is leakage, more often then not it would result in a subperiosteal abscess, and many of those do not result in any limitation of motility. So, it is hard to put this together as a cause-and-effect relationship with that kind of evidence.

Dr. Irene H. Ludwig. With regard to the questions of Dr Stager, I don't have good incidence figures on normal CT scans in this series. This was a gradual evolution of thinking, and I kept records on patients who had what I suspected to be positive sinus-related strabismus. I have now started to collect more data. My impression is that when I do suspect possible sinus-related strabismus, I find severe sinus disease about 50 percent of the time. A number of ENT colleagues have related that I have sent them some of the most challenging sinus cases they have seen. There are other patients who have evidence of extraocular muscular fibrosis without evidence of thyroid disease and with negative CT scans. They may have other causes of acquired muscle fibrosis, such as rheumatologic disorders. I have some patients with strabismus and rheumatologic disorders, which may be related. Their findings are often similar to the findings in sinus-related strabismus.

It is difficult to measure young children for incomitance. The adults in this series often demonstrated mild incomitance, such as an esotropia of 25 diopters in the primary position and 35 diopters on side gaze, suggesting tightness of the medial recti or mild weakness of the lateral recti. When I perform force generation testing on these patients, they have strong muscles with no evidence of muscle palsy.

Alignment testing with prism and alternate cover for fourth cranial nerve palsy is inadequate without evaluation of torsion. The three-step test in a patient with acquired vertical strabismus due to inferior rectus fibrosis is identical to the measurements in a contralateral fourth cranial nerve palsy. The fundus exam, however, demonstrates extorsion in the lower eye when inferior rectus fibrosis is present. The forced duction test is very helpful, although the force generation test for the superior oblique is very subtle and very weak.

How might you possibly cause a high AC/A ratio with this problem? It might occur with a slight shortening of the extraocular muscles, not enough to affect the primary position or the distance alignment, but just enough that the patient can't control alignment at near. We know that medial rectus recession will decrease a high AC/A relationship, and we know that a low AC/A relationship can be collapsed with a slight resection of the medial rectus. Therefore, it is certainly possible to develop a high AC/A relationship from a slight shortening of the medial rectus.

I do not have a good animal model or imaging method yet to look at inflammation in the eye muscles. I have consulted with several investigators at LSU but still have not been able to develop an animal model of sinusitis and strabismus. We have been developing a convenient muscle hook with a built-in strain gauge to measure length-tension curves on all surgical strabismus patients. Sinus-related strabismus patients have stiffness in their muscles, but this is a subjective finding. It would be better to have objective documentation of muscle stiffness. Sinus treatment probably does not improve muscle compliance in patients unless the process is caught early. Most of these people have had prolonged sinus disease and the best I hope for is arrest of progression. There are a number of people in this series who had strabismus recurrences. I straightened their eyes, but six months later, the strabismus recurred due to unrecognized preoperative sinusitis. It was not until the sinus disease was controlled that the strabismus stabilized.

The extraocular muscle may not be the only tissue affected by the adjacent sinusitis. The motility restrictions may be created more from the orbital tissues, the orbital septae, and the connections to the eye muscles. The patients that develop sinusitis and then diplopia probably have different orbital defects. I have a few anecdotal cases not in this series where patients have known orbital trauma with good alignment after surgery but then develop a sinus infection and strabismus.

To answer Dr Mazow's question about orbital cellulitis and strabismus incidence, I have seen only a few cellulitis cases, and they did not have strabismus. The patients who develop strabismus have chronic, long-term inflammation that may recur periodically over years before manifestation of strabismus. I have the impression that the patients who develop the most problems are the ones with posterior sinus disease. Their sinuses don't drain, and they are unaware of their sinus disease. As cellulitis is treated promptly, chronic extra-ocular muscle fibrosis probably does not have time to develop.

In answer to Dr Flach's question, I have one patient who had thyroid ophthalmopathy with an orbital decompression and extraocular muscle surgery. He indicates that every time he has a sinus infection, his strabismus returns. With prompt use of oral antibiotics and extensive exercise of his extraocular muscles, the strabismus resolves. This is just one anecdotal case, but it is an interesting one.

In response to Dr Ritch's discussion, there is one patient in my series who developed what was diagnosed a fourth cranial nerve palsy. Being a physician, he knew that the maxillary sinus was adjacent to the eye muscles, so he treated himself with antibiotics. Within a day, the strabismus resolved. I would welcome any references you can add to my search.

To answer Dr Friedman's question, I did not find obvious extraocular muscle changes on imaging study in my patients. I do not have access to EMGs in my practice. I do not obtain tissue for histopathologic evaluation on these patients since I have been taught to avoid disrupting the extraocular muscle tissue. Obtaining a biopsy of an extra-ocular muscle could cause increased fibrosis and adhesion.

Dr Flynn, the eye muscle stretching exercises in a young child are performed by having the parents use a target, like a toy, and encouraging the child to rotate the eyes into side gaze, upgaze, and up and obliquely to the corners since the superior obliques are often tight in these cases. For adults, it's easier to teach them to fixate on a target, such as a television, and then have them rotate the head and hold the eyes in extreme side and upgaze for prolonged periods of time.

Dr Bartley, we did not perform cultures on these patients. Their otolaryngologists, following prolonged antibiotic use, performed the sinus surgeries.

Dr Raab commented on the number of sinusitis patients who don't have motility restrictions. The ones that do not develop problems with strabismus are the ones who are draining or who are being treated promptly. It is the patient who is unaware of his sinus disease who seems to present with strabismus.