Vocal fold nodules (VFNs) are benign lesions that appear at the junction of the anterior and middle thirds of the vocal fold. They develop as a result of trauma arising from contact between the opposing surfaces of the vocal folds, generally related to voice overuse or to repetitive vocal abuse and vocal strain. Multiple factors may act to create an environment more conducive to VFN formation, including gastroesophageal reflux, allergy, sinusitis, postnasal drip, and chronic cough. There may be a genetic predisposition toward the development of nodules as well.1

Among hoarse pediatric patients, VFNs are the most frequently found pathological condition of the larynx.2 Their prevalence among school-aged children is high, estimated at 16.9%.3 Commonly used treatments for pediatric VFNs include (1) behavioral management to guide children toward improved vocal hygiene, (2) direct voice therapy, and (3) treatment of exacerbating factors such as allergic rhinitis or gastroesophageal reflux. Surgery to remove VFNs is generally reserved for patients with severe cases and those whose VFNs do not respond to more conservative treatment.

Many clinicians advocate for conservative treatments initially because VFNs resolve spontaneously at puberty in the majority of children, particularly in boys.1,4 Vocal behaviors including excessive or aggressive voice use that may lead to
VFN formation often subside as a child matures. However, it has been shown that pediatric hoarseness can have an adverse effect on how others perceive a child and on the child’s self-perception. Thus, although many cases eventually resolve without treatment, it is important to have effective treatment options for children who are more severely affected.

There remains little in the literature about the evolution of pediatric VFNs over time. This study was designed to investigate the rate of change in pediatric VFN size over time and to identify which factors influence increased rates of improvement in VFN size.

Methods

This retrospective study was approved by the institutional review board at Boston Children’s Hospital. The requirement for patient consent was waived by the institutional review board as a result of the retrospective nature of the study. Children evaluated from 2002 to 2011 in the Voice Clinic at Boston Children’s Hospital with a primary diagnosis of VFNs were studied. Transnasal videostroboscopic examination was performed for all patients. An FNL-10RP3 fiberoptic nasolaryngoscope (KayPENTAX) was used to capture video and still images in children aged 13 years and older; a KayPENTAX FNL-7RP3 fiberoptic nasolaryngoscope was used in children 3 to 12 years of age.

The nodules were reviewed on the still images, as well as on video clips, by one of us (R.C.N.) and graded according to a previously validated, published scale. Specifically, nodules were graded 1, 2, or 3. A grade 1 nodule protruded less than 0.5 mm from the vibratory edge, allowing for complete adduction of the glottis; a grade 2 nodule protruded 0.5 to 1.0 mm from the vibratory edge, often resulting in an anterior glottic gap on adduction; a grade 3 nodule protruded more than 1.0 mm from the vibratory edge, resulting in an hourglass formation of the glottis on adduction.

Vocal fold nodule grade was analyzed by means of a 2-step method described by Feldman. First, for each patient who had at least 2 time-linked data points for nodule grade, the earlier nodule grade was set as baseline. A simple linear regression was performed to each child’s nodule grades and time since baseline, generating a slope. The slope then represents the change in nodule grade per month.

The slopes were then analyzed in relation to several factors, including sex, baseline nodule size, treatment, and patient age, to evaluate for a potential effect on the slope. Treatment groups included group 1, no treatment or behavioral modification only; group 2, targeted voice therapy with or without the treatment of associated conditions (gastroesophageal reflux and allergic rhinitis); and group 3, surgical intervention. A 2-sided type I error level of #alpha# = .05 was used for all analyses. All the analyses were conducted in SAS, version 9.3 (SAS Institute).

Results

Sixty-seven patients with a median (range) age of 6.0 (3.8-20.6) years were analyzed. The male to female ratio was 2.35:1. Median (range) follow-up was 25 (1-119) months.

The mean (SD) slope (change in grade/time [months]) was #−0.03 (0.12), with a median (range) of #−0.01 (−0.94 to 0.06) (Figure 1). The median (range) slope was not significantly different between boys (#−0.01 [−0.94 to 0.05]) and girls (0.00 [−0.20 to 0.06]; #P# = .63). The slope was significantly associated with baseline VFN size (P < .001), with an increased rate of improvement in VFN size observed for those children with larger baseline VFN size. In particular, the median (range) slope for those with VFNs of grade 3 (n = 28) was #−0.04 (−0.94 to 0.00) vs 0.00 (−0.20 to 0.06) for those with VFNs of grade 1 or 2 (n = 39). Considering this monthly change in grade, we extrapolated that for children with baseline VFN grade 3, it would take approximately 2 years (25 months) to observe a decrease from grade 3 to grade 2. In contrast, minimal change is expected over time for those children with a baseline VFN grade of 1 or 2 (Figure 2A).

The rate of change in VFN size was significantly associated with treatment, with a greater rate of improvement seen in those children receiving voice therapy with or without the management of associated conditions or those undergoing surgery. Those whose treatment consisted of observation or behavioral modification (n = 19) had a median (range) slope of 0.00 (−0.08 to 0.06) vs those receiving targeted voice therapy with or without the treatment of associated conditions (n = 45) with a median (range) slope of #−0.03 (−0.94 to 0.05) (P = .01) vs those undergoing surgery (n = 3) with a median (range) slope of #−0.08 (−0.09 to 0.00). In this way, it could be expected to take approximately 3 years (33.3 months) to observe 1 full grade decrease in VFN size for those children undergoing voice therapy with or without the treatment of associated conditions. In those undergoing surgery, it could be extrapolated to take approximately 1 year (12.5 months) to observe 1 full grade decrease in VFN size. Finally, minimal change in VFN size could be expected for those children who are observed or receive instruction regarding behavioral modification (Figure 2B).
Finally, there was an increased rate of improvement in VFN size seen in the postpubescent age group, those older than 13 years (n = 7), with a median (range) slope of −0.06 (−0.20 to 0.00) vs those 13 years or younger (n = 60), with a median (range) slope of 0.00 (−0.94 to 0.06) (P = .09). Extrapolation of these slopes suggests that for those in the postpubescent age group, it would take approximately 1.5 years (16.7 months) to observe a decrease in VFN size by 1 full grade. Conversely, in the prepubescent age group, very small increments of improvement could be expected (Figure 2C).

Change in the grade of the VFN size during periods of 1 and 3 years was next examined. The rate of change in size of the VFNs was not significantly different at 1 and 3 years (P = .33). For years 1 and 3, the median (range) slope was −0.01 (−0.94 to 0.04) and 0.00 (−0.08 to 0.04), respectively.

Discussion

To our knowledge, this study is unique in providing longitudinal information regarding the rate at which pediatric VFNs evolve and the factors that influence this change. Baseline VFN size, treatment, and patient age were found to be important factors in predicting the rate of improvement in nodule size over time. In addition, the rate of change in VFN size observed was a gradual decrease that was steady over periods of 1 and 3 years. An increased rate of improvement was observed for those children with larger baseline VFN size. It is postulated that larger nodules may show increased effect from voice therapy, vocal hygiene, or treatment of associated medical conditions (a relatively more "induced change"), whereas the change from moderate to small nodules required more effort.

In terms of treatment, those children participating in voice therapy or without the treatment of associated conditions experienced an increased rate of improvement in VFN size, as compared with those who were observed or received instruction regarding behavioral modification. Possible reasons for the increased rate of improvement in those undergoing voice therapy or without the treatment of associated conditions are several. First and foremost, the improvement could be due to use of the techniques learned and reinforced during voice therapy sessions and/or the control of exacerbating conditions such as allergy or reflux. This group may also represent children who are more severely affected in terms of voice quality or families who are more motivated to adhere to treatment recommendations. Other studies have examined how treatment influences change in pediatric VFNs. These studies have measured progress via perceptual voice measures. Mori8 examined the effects of treatment, namely, vocal hygiene, voice therapy, and surgery, on VFNs using either parental or self-perception of voice. Overall, 16% of children using vocal hygiene advice, 52% of those receiving voice therapy, and 89% of those who underwent microsurgery showed some improvement in overall voice quality. For the prepubertal subgroup, no significant differences were found among the vocal hygiene, voice therapy, and no treatment groups, whereas surgery was found to consistently result in improvement. In contrast, no significant difference was found in the postpubertal subgroup among the 4 treatment modalities, with almost all patients improving. De Boodt et al4 found similar outcomes, with no correlation between voice complaints after puberty and the type of therapy previously received in childhood. We observed an overall increased rate of improvement in VFN size in the postpubescent age group, in
which it was extrapolated to take approximately 1.5 years to observe a decrease in VFN size by 1 full grade. In contrast, in the prepubescent age group, very small increments of improvement were observed over time. Possible explanations for the increased rate of improvement in the postpubertal age group include hormonal changes related to puberty, improvement in vocal hygiene with maturation, or improved adherence to treatment recommendations. In addition, the increased rate of growth of the vocal folds during adolescence may result in a change in the location of maximal shear stresses during phonation. In effect, this moving target of phonation-related vocal trauma may help decrease trauma to previously formed nodules, with a subsequent decrease in their size. As a next step, we plan to examine prepubertal and postpubertal subgroups, evaluating for whether the aforementioned treatment effects persist for both subgroups.

De Bodt et al.4 examined the evolution of VFNs from childhood into adolescence and found a significant sex difference. Overall, 21% of the study group reported voice complaints that persisted into adolescence; this included 37% of the girls and 8% of the boys. Objective data were found to correlate with the perceptual data, with VFNs persisting in 47% of girls and 7% of boys. In the present study, sex was not significantly correlated with the rate of change of VFN size. However, the median age of our patient population was young (6 years); thus, a sex difference may have become more apparent with an older patient population.

A shortcoming of the present study is that measures of voice analysis were not available for all patients, making it impossible to analyze perceptual assessment of voice quality or acoustic measures over time. It may be hypothesized that improvement in laryngoscopic findings does not translate into improved voice quality. Prior studies are conflicting in terms of whether there is a direct correlation between the size of VFNs and voice quality. Shah et al.5 did not find a significant correlation between VFN size and objective voice measures but noted that laryngoscopic findings correlated only with pitch reduction. In many other categories, both acoustic and perceptual, interesting although statistically insignificant differences were noted, with voice measures worsening as nodule size increased. That study, however, had limitations in that a validated instrument for the perceptual assessment of voice quality was not used. In a study by Nuss et al.,6 a significant correlation was found between nodule size and measures including roughness, strain, pitch, loudness, and overall severity. Additional study is needed to evaluate whether the same factors that influenced a greater rate of improvement in VFN size similarly result in improved acoustic measures, as well as parental and professional perception of voice quality.

Conclusions

The treatment plan for children with VFNs is an individualized one. In formulating a plan, one must take into account the age of the patient, the patient’s motivation and ability to adhere to therapy, and the degree of dysphonia and its impact on daily functioning. The present study provides information that may help to better guide treatment decisions and to better educate patients’ families in setting reasonable expectations and time course for improvement. Additional investigation is needed to look into whether the findings in the present study persist regardless of prepubertal or postpubertal patient age and to determine whether the same factors that affect an increased rate of improvement in the size of the VFN also result in improved measures on acoustic and perceptual voice analyses.

ARTICLE INFORMATION

Submitted for Publication: June 18, 2013; final revision received October 29, 2013; accepted November 21, 2013.


Author Contributions: Drs Nardone and Nuss had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Nardone, Nuss. Acquisition of data: Nardone, Recko, Nuss. Analysis and interpretation of data: Nardone, Huang, Nuss. Drafting of the manuscript: Nardone. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: Huang. Administrative, technical, or material support: Recko, Nuss. Study supervision: Nardone, Nuss.

Conflict of Interest Disclosures: None reported.

Previous Presentation: This study was presented at the 2013 American Society of Pediatric Otolaryngology Spring Meeting; April 28, 2013; Arlington, Virginia.

REFERENCES