Measurements of adult lingual tonsil tissue in health and disease

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

ABSTRACT

OBJECTIVES: To report computed tomography (CT) measurements of lingual tonsil tissue (LTT) in patients with laryngopharyngeal reflux (LPR), obstructive sleep apnea-hypopnea syndrome (OSAHS), both LPR and OSAHS, or neither disease.

STUDY DESIGN: Retrospective chart review.

SETTING: Tertiary care center.

SUBJECTS AND METHODS: Ninety-eight patients with CT scans including the tongue base and complete historical data regarding the presence or absence of symptoms, signs, and laboratory confirmation of LPR and/or OSAHS were included. LTT was measured on CT. Charts of patients meeting inclusion criteria were subsequently reviewed and patients were divided into four groups: 1) those without LPR or OSAHS, 2) those with LPR only, 3) those with OSAHS only, and 4) those with both LPR and OSAHS. Statistical analysis focused on correlating LTT thickness with the presence or absence of LPR and/or OSAHS.

RESULTS: The mean LTT thickness for group 1 (21 patients without reflux or OSAHS) was 0.937 mm (range 0-2.67 mm). The mean for group 2 (29 patients with LPR only) was 3.35 mm (range 0-7.4 mm). The mean for group 3 (16 patients with OSAHS only) was 4.29 mm (range 0-9 mm). The mean for group 4 (32 patients with LPR and OSAHS) was 4.00 mm (range 0-19.2 mm). The mean for group 1 was lower than the other 3 groups (P < 0.001).

CONCLUSION: CT images including the tongue base allow precise measurement of LTT thickness. LTT > 2.7 mm was not identified in patients without OSAHS or LPR. The mean LTT for patients with LPR and/or OSAHS was significantly greater than for patients without either disease.

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Lingual tonsil tissue (LTT) is present to a variable degree in most individuals. Typically, it is more evident in children and adolescents and tends to regress with advancing age.1 Hyperplastic LTT has been distinguished from “normal” size lingual tonsils and designated as “lingual tonsil hypertrophy” (LTH). LTH has been implicated as a contributing factor to airway obstruction in obstructive sleep apnea/hypopnea syndrome (OSAHS).2-5 Although LTH may have various causes, it has recently been linked specifically to laryngopharyngeal reflux (LPR). Despite widespread recognition of the significance of LTH, no standardized system has been established to measure LTT. The purpose of this study was to utilize CT images of the base of the tongue to determine the thickness of LTT in patients diagnosed with OSAHS, patients diagnosed with LPR, patients diagnosed with both conditions, and patients without either pathology.

Subjects and Methods

This study was approved by the Advocate Health Care Institutional Review Board (Chicago, IL). Patients were selected according to the following procedure (Fig 1). Seven-hundred and twenty patients were scheduled for a CT scan of the sinuses, neck, or cervical spine in the office of the principal investigator (M.F.) during the period from January 2009 to June 2009 for reasons other than this study. Of these, 135 patients agreed to participate in this study. CT scans performed on these patients included the base of the tongue. Images were reviewed, and measurements of LTT thickness were recorded prior to reviewing patient charts for evidence of OSAHS, gastroesophageal reflux disease (GERD), or LPR. Data from 98 patients who met the following inclusion criteria were analyzed: 1) age 18 to 80 years, 2) CT scan, contrast or noncontrast, including the tongue base, and 3) charted documentation regarding the presence or absence of GERD-, LPR-, or OSAHS-related symptoms. No patient underwent CT for the sole purpose of participating in this study. Patients with a history of radiation or a malignancy of the head and neck region were excluded, as were any patients who underwent CT scan to evaluate an infectious process.

CT scans were reviewed by a board-certified radiologist (G.G.) and one author (M.W.), both of whom were blinded...
to the indication for the CT and to patient history. The lingual tonsils, which appear as hyperdense tissue in the lingual fossa at the posterior aspect of the tongue in both contrast and noncontrast images, were identified and measured by both reviewers. Because LTH is not always symmetric around the midline, LTT thickness was measured in the anterior-posterior dimension at the midline and at points to the left and right where thickness was greatest. The three points were averaged to yield a mean LTT thickness for each patient. After each investigator had measured the LTT, results were compared. If there was a discrepancy regarding a patient’s measurements, the images were reviewed again by both investigators, and a consensus was reached.

Once LTT thickness was determined, the chart of each patient was reviewed to collect data regarding history of reflux (GERD or LPR), OSAHS, malignancy, or radiation therapy involving the head and neck, and the indication for the CT. Patients who failed to meet all inclusion criteria were excluded. All patients were screened by questionnaires, history, and physical examination for OSAHS and LPR. Patients were categorized as having reflux if they had a positive 24-hour pH study on testing with the Restech Dx-pH probe (Restech, San Diego, CA) or if they reported symptoms of LPR (e.g., cough, throat clearing, dysphonia, etc.) in the presence of physical examination findings to support the diagnosis (e.g., erythema, edema, and cobblestoning) on laryngoscopy. Patients who lacked signs and symptoms of reflux and those who had a negative pH study were categorized as not having a history of reflux. Patients who had a history suggestive of OSAHS underwent polysomnography. Those with an apnea-hypopnea index (AHI) of ≥ 5 events/hour were considered to have OSAHS.

Patients were divided into four groups on the basis of clinical and diagnostic findings. Group 1 included patients without signs, symptoms, or diagnostic evidence of OSAHS or LPR; group 2 included those diagnosed with LPR only; group 3 included those with evidence of OSAHS only; and group 4 included those with both OSAHS and LPR.

### 24-Hour pH Monitoring

The diagnosis of LPR was made in 18 patients by 24-hour pH monitoring using the Restech Dx pH probe. A single-use pH probe was calibrated for each patient using standard buffer solutions, according to manufacturer protocol, prior to insertion via one of the nares. The probe was positioned such that the flashing LED contained within the tip was visible just posterior to the soft palate. Patients were asked to keep a record detailing the time and duration of reflux symptoms, periods of recumbency, and ingestion of food or liquids during the study. Patients were also instructed to keep track of the same information by pushing the corresponding buttons on the device recorder. Information gathered from these two sources was crosschecked prior to analyzing the data downloaded from the device into the DataView software (Restech). A study was considered positive if the software-generated Ryan score was > 9.41 when the patient was in the upright position or > 6.80 when the patient was in the supine position. The Ryan score is calculated based on the number of episodes in which pH falls below the normal range, the longest length of time during which pH remains below this threshold, and the total percentage of time spent below threshold.

### Polysomnography

In patients with suspected OSAHS, an all night, attended, comprehensive sleep study was performed using a computerized polygraph to monitor electroencephalogram (C3-A2, C4-A1), left and right electro-oculogram, electrocardiogram, chin and anterior tibialis electromyogram, abdominal and thoracic movement by inductive plethysmography, nasal and oral airflow, arterial oxygen saturation by pulse oximetry (SpO₂), and throat sonogram. Apnea was defined as cessation of breathing for at least 10 seconds. Hypopnea was defined as a decrease in airflow of at least 50 percent from baseline with a minimum four percent decrease in SpO₂. The AHI was calculated as the sum of total events (apneas and hypopneas) per hour. An AHI ≥ 5 was considered diagnostic of OSAHS.
CT Imaging

CT scans were performed using a Toshiba Aquilon 16 CT scanner (Toshiba America Medical Systems, Inc., Tustin, CA). Images were viewed with the iQ-view system v2.5 (IMAGE Information Systems, London, UK), which allowed for the generation of sagittal reconstructions. Images were reviewed by two investigators, including a board-certified radiologist (M.W. and G.G.). LTT thickness was measured on both sagittal and axial views using the measurement tool on the iQ-view v2.5 system (Figs 2 and 3).

Statistical Analysis

All statistical analyses were performed using SPSS for Macintosh Version 16.0 (SPSS, Inc., Chicago, IL). Continuous data are displayed as mean ± standard deviation (SD). Statistical significance was accepted as $P < 0.05$. The one-way analysis of variance (ANOVA) and Student-Neuman-Keuls test were used to identify significant differences in continuous variables among the four groups. The independent Student’s t-test was used to determine statistically significant differences in continuous variables when only two groups were being compared. The $\chi^2$ test was used to determine significant differences between groups for categorical variables. Multiple regression analysis was performed using a backwards stepwise method using OSAHS,

Figure 2  The patient in these images had minimal lingual tonsil tissue (arrows), as displayed in the sagittal (A) and axial (B) views.

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Figure 3  The patient in these images had enlarged lingual tonsil tissue (arrows) that can be seen in both the sagittal (A) and axial (B) views.
LPR, and OSAHS plus LPR as possible independent variables and LTH as the dependent variable. A regression equation was constructed using significant variables and a constant. The Pearson correlation coefficient was calculated.

Results

Charts were reviewed from 135 patients whose CT scans allowed visualization of the tongue base. Ninety-eight patients met inclusion criteria for the study (Table 1). Group 1 consisted of 21 patients without OSAHS or LPR. The mean age for this group was 51.9 ± 23.1 years, and 47.6 percent were male. LTT thickness in this group ranged from 0 to 2.67 mm, with a mean of 0.937 ± 0.967 mm and a median of 0.9 mm. Group 2 consisted of 29 patients with reflux only. The mean age in this group was 46.5 ± 15.8 years, and 58.6 percent were male. LTT thickness in group 2 ranged from 0 to 7.4 mm, with a mean of 3.35 ± 2.13 mm and a median of 3.5 mm. Group 3 comprised 16 patients with OSAHS only. The mean age was 46.5 ± 15.8 years, and 87.5 percent of these patients were male. Mean AHI in this group was 4.02 mm and a median of 3.08 mm. Group 4 consisted of 32 patients with both reflux and OSAHS. The mean age was 49.6 ± 9.00 years, with a mean of 4.29 ± 3.08 mm, and a median of 4.02 mm and a median of 3.08 mm.

Based on one-way ANOVA and the Student-Neuman-Keuls test, the mean LTT thickness of group 1 was found to differ significantly from that of the other groups (P = 0.001). The remaining groups did not differ from one another significantly. The mean age for each group did not vary significantly on one-way ANOVA (P = 0.418).

Regression analysis of LTT thickness with respect to the presence of OSAHS and/or reflux revealed significant relationships between LTT thickness and OSAHS alone (R = 0.294, P = 0.007) and between LTT thickness and OSAHS with reflux (R = 0.375, P = 0.003). Reflux by itself was not significantly correlated with LTT thickness.

Discussion

A number of studies have examined the interplay between OSAHS, LPR, and LTH. Some evidence exists to support reflux as a cause of LTH, which, in turn, can contribute to OSAHS. The latter condition has also been postulated to cause LTH by provoking LPR. Although the relationship between these three conditions has yet to be fully elucidated, significant evidence exists to assert LTH as a likely cause of airway obstruction in OSAHS.

Recent studies suggest that persistent LTH in adults is a result of untreated LPR. DelGaudio et al demonstrated a trend between increasing LTH severity and increasing frequency of LPR episodes detected on 24-hour pH monitoring. The severity of LTH in this study was assessed by laryngoscopy and graded as mild, moderate, or severe. Mamede et al also found a positive correlation between symptoms of gastroesophageal reflux and the presence of LTH. In this study, LTH was considered present when the lymphoid follicles prevented visualization of the vallecula on laryngoscopy.

LTH in the setting of LPR is thought to result from the edema and tissue inflammation caused by repeated exposure of the mucosa to refluxed acid. The resulting thickened and inflamed LTT may narrow the retrolingual airway, increasing the likelihood of airway obstruction and apnea events. While treatment of reflux has been shown to decrease indices of OSAHS severity in some patients, a causal rela-

Table 1

<table>
<thead>
<tr>
<th>Group 1: no LPR or OSAHS (n = 21)</th>
<th>Group 2: LPR only (n = 29)</th>
<th>Group 3: OSAHS only (n = 16)</th>
<th>Group 4: LPR + OSAHS (n = 32)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>51.9 ± 23.1</td>
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<td>42.9 ± 14.8</td>
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<td>Male</td>
<td>11</td>
<td>12</td>
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<td>10</td>
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<tr>
<td>LTT thickness (mm)</td>
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<td></td>
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</tr>
<tr>
<td>Range</td>
<td>0–2.67</td>
<td>0–7.4</td>
<td>0–9.0</td>
<td>0–19.2</td>
</tr>
<tr>
<td>Mean</td>
<td>0.937 ± 0.967</td>
<td>3.35 ± 2.13</td>
<td>4.29 ± 2.60</td>
<td>4.0 ± 4.02</td>
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<td>Median</td>
<td>0.9</td>
<td>3.5</td>
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<td>Mean AHI (events/h)</td>
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<td>n/a</td>
<td>30.7 ± 23.8</td>
<td>33.4 ± 26.2</td>
</tr>
</tbody>
</table>

LTT, lingual tonsil tissue; AHI, apnea-hypopnea index; n/a, not applicable.

*Significance accepted at P < 0.05.
†Based on one-way analysis of variance (ANOVA) and Student-Neuman-Keuls analysis.
‡Based on χ² analysis.
§Based on independent Student t-test.
tionship between reflux and OSAHS has not yet been proven.

Whether LTH is implicated as a cause or result of a disease process, a clear definition of what constitutes LTH and a precise method for quantifying LTT are both vital to elucidating the role that LTH plays in OSAHS and LPR. Visual assessment of lingual tonsil size is subject to inter-examiner variability, and has poor sensitivity for detecting subtle changes in size. The need for a more precise method of assessing LTT that is less prone to interobservation variation is inarguable. Our results show that CT can be used to fill this void. Although further studies will need to be performed before normative measurements of LTT and a grading system for LTH severity can be established, CT clearly provides a precise means for describing LTT in objective terms. Moreover, CT images can serve as a visual record that may be used to track changes in LTT over time and in response to therapy. No previous studies have measured lingual lymphoid tissue on CT, magnetic resonance imaging, or another radiologic imaging technique.

Because lymphoid hyperplasia is far more common in children and young adults, LTH as a contributing factor to airway obstruction in OSAHS may be more frequent in that group compared to older adults. While not determined to be statistically significant, the mean age of the group with the greatest mean LTT thickness, group 3 (OSAHS only), was nearly a decade younger than the group with the lowest mean LTT thickness, group 1 (neither LPR nor OSAHS). Further research using larger sample sizes and groups with more closely matched ages will be necessary to eliminate age as a confounding factor.

This study suffers from a major deficiency in that 24-hour pH monitoring was not used to confirm the diagnosis of LPR for every patient. The number of patients who did undergo this testing was insufficient for valid statistical analysis. As a consequence, we were unable to draw any conclusions regarding severity of reflux versus degree of LTH. Furthermore, since the diagnosis of LPR relied on visual inspection of the upper airway during laryngoscopy, the presence or absence of LTH may have unintentionally influenced whether or not a diagnosis of LPR was made. In addition, although all patients underwent general screening for LPR and OSAHS, a formal protocol for excluding either diagnosis was not established. Thus, as clinical symptoms and physical findings are neither 100 percent sensitive nor 100 percent specific in the diagnosis of LPR and OSAHS, it is possible that some patients who did not undergo pH monitoring or polysomnography, respectively, were misdiagnosed. Despite the abovementioned limitations, the significant difference in LTT measurements between the patients without LPR or OSAHS compared to those with one or both of the conditions suggests a clear trend worthy of further investigation.

Utilizing CT imaging as opposed to relying solely on physical examination and endoscopy for assessing LTT is obviously limited by the associated high cost and radiation exposure. It is not the objective of this article to propose that CT imaging be performed routinely for all patients with signs or symptoms suggestive of LPR or OSAHS. Rather, the purpose of this study is to provide evidence to support CT imaging as a method for obtaining objective measures of LTT. This may prove to be an important metric for future studies that seek to examine the relationship of LTH with another disease process. Further investigation is necessary in order to establish normative values for LTT upon which a grading scale for LTH severity can be based. The degree to which age influences what is to be considered within normal range for LTT is another interesting topic that warrants additional research.

Conclusion

CT images that include the base of the tongue provide the means for precise measurement of LTT thickness. LTT thickness > 2.7 mm did not occur in any patients without OSAHS or LPR. The mean LTT thickness of patients with LPR and/or OSAHS is significantly greater than that of patients without either disease. Further research is necessary to establish normative values for LTT in health and disease for patients from various age groups.

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This article was presented at the 2009 AAO-HNSF Annual Meeting & OTO EXPO, San Diego, CA, October 4-7, 2009.

Author Contributions

Michael Friedman, study design and conception, literature review, data analysis and interpretation, manuscript preparation; Meghan N. Wilson, study design, data collection, analysis, and interpretation, manuscript preparation; Tanya M. Pulver, data collection, analysis, and interpretation, manuscript preparation; Dina Golbin, data collection; George P. Lee, data collection; Gleb Gorelick, data collection; Ninos J. Joseph, statistical analysis.

Disclosures

Competing interests: Michael Friedman, TriCord Pharmaceuticals: grant recipient for study regarding nasal irrigation as treatment for sinonasal symptoms; Glaxo-Smith-Kline: member of speakers bureau.

Sponsorships: None.

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