Introduction

Advances in magnetic resonance imaging (MRI) and computed tomography (CT) technology have opened new dimensions for understanding anatomy and physiology of head and neck lesion. However, practical application is limited by radiation exposure, cost, accessibility and complexity. Furthermore, evaluation of 3-dimensional (3D) glottic insufficiency is difficult because of the required scanning time of more than 10 seconds. Image intensifier-based laryngeal CT imaging was previously used as a special procedure to treat glottic insufficiency. Fiberoptic or rigid laryngoscopy is an easy diagnostic procedure to observe the 2D pathology, but these procedures are unsatisfactory to provide virtual information. Cone-beam CT (CBCT) technology (CBCT) was developed for the office-based quick and precise 3D visualization of maxillofacial region. CBCT requires short scanning time of less than 10 seconds and provides isotropic 3D image with high resolution. In this study, we examined the potential role of CBCT as a tool for 3D evaluation of glottic insufficiency.

Table 1. Potential Advantages of CBCT compared to conventional CT or MRI

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Conventional CT</th>
<th>CBCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning time</td>
<td>More than 10 seconds</td>
<td>Less than 10 seconds</td>
</tr>
<tr>
<td>Radiation exposure</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Cost</td>
<td>More expensive</td>
<td>More expensive</td>
</tr>
</tbody>
</table>

Results

CBCT of the vibrating vocal fold was successfully performed in all the cases producing clear multi planar reformatted (MPR) 2D images and reconstructed 3D images (Figure 1). Since evaluation of vertical level of the vocal folds during contraction of laryngeal muscles is important to select proper surgical procedure for glottic insufficiency, we focused on the evaluation of vertical images in the patients with unilateral vocal fold paralysis. CBCT imaging 9 seconds for scanning and maximum resolution time (MPT) of the patients with unilateral vocal fold paralysis are less than 10 seconds in most of the cases while they can tolerate the contraction of laryngeal muscles more than 10 seconds with straining their abdomens. Thus we first investigated if the scanning condition could substitute for vocalizing condition to examine the glottic shape and position during contraction of laryngeal muscles. Coronal images at the resting state (R), during vocalization (V) and during straining abdomen (S) were compared in a normal control (Figure 2). From these images, we found that the glottic insufficiency was more severe in the S condition compared to V condition and no remarkable differences in vertical levels of the vocal folds were observed between S and R conditions. Thus we could substitute for vocalizing condition to examine the glottic shape and position during contraction of laryngeal muscles more than 10 seconds with straining their abdomens. Thus we first investigated if the straining condition could substitute for vocalizing condition to examine the glottic shape and position during contraction of laryngeal muscles. Coronal images at the resting state (R), during vocalization (V) and during straining abdomen (S) were compared in a normal control (Figure 2). From these images, we found that the glottic insufficiency was more severe in the S condition compared to V condition and no remarkable differences in vertical levels of the vocal folds were observed between S and R conditions. Thus we could substitute for vocalizing condition to examine the glottic shape and position during contraction of laryngeal muscles more than 10 seconds with straining their abdomens. Thus we first investigated if the straining condition could substitute for vocalizing condition to examine the glottic shape and position during contraction of laryngeal muscles.

Discussion

CBCT was performed in 3 normal controls and in 22 patients who visited our hospital with a symptom of globus sensation in the laryngopharyngeal region. CBCT images were taken in 2 conditions. First condition was the resting state and the second condition was during phonation or straining abdomen (Figure 3). Postoperative CBCT images were evaluated to assess the impact of phonosurgeries in 10 cases with unilateral vocal fold paralysis.

Postoperative CBCT imaging was useful to evaluate the impact of phonosurgeries. This quick and easy system may have an informative role to suggest the proper phonosurgical procedure for glottic insufficiency.

Table 2. Patients Undergoing Phonosurgery

<table>
<thead>
<tr>
<th>Case</th>
<th>Laterality</th>
<th>Glottal Gap</th>
<th>MPT (sec)</th>
<th>MFR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>1</td>
<td>Left</td>
<td>20</td>
<td>19</td>
<td>273.2</td>
</tr>
<tr>
<td>2</td>
<td>Right</td>
<td>20</td>
<td>1</td>
<td>866.5</td>
</tr>
<tr>
<td>3</td>
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<td>5</td>
<td>446.5</td>
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<tr>
<td>4</td>
<td>Right</td>
<td>20</td>
<td>7</td>
<td>866.9</td>
</tr>
<tr>
<td>5</td>
<td>Left</td>
<td>20</td>
<td>3</td>
<td>446.4</td>
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<tr>
<td>6</td>
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<td>20</td>
<td>10</td>
<td>469.8</td>
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<td>17</td>
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<td>20</td>
<td>20</td>
<td>592.7</td>
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<tr>
<td>9</td>
<td>Right</td>
<td>10</td>
<td>5</td>
<td>295.4</td>
</tr>
</tbody>
</table>

Conclusions

This is the first study to show the feasibility of CBCT for 3D evaluation of laryngeal insufficiency. CBCT evaluation of laryngeal muscles was successfully performed on 3 normal controls and 22 patients with glottic insufficiency. CBCT images were taken in 2 conditions: resting state and during phonation. Coronal images were taken during phonation or straining abdomen (Figure 3). Postoperative CBCT imaging was useful to evaluate the impact of phonosurgeries. This quick and easy system may have an informative role to suggest the proper phonosurgical procedure for glottic insufficiency.