Relationship of Perceptual Evaluation for Resonance Disorders to Nasalance Scores in Children with Cleft Palate

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Objective: To determine relationship between screening perceptual assessment for resonance disorders and nasalance scores.

Material and Method: Screening perceptual assessment of 115 children with cleft palate with or without lip was performed to determine its relationship to nasalance scores. The perceptual assessment 3-scale (-1: hyponasality; 0: normal; +1: hypernasality) was compared to nasalance scores based on nasometry. To find the weight of Kappa, nasalance scores were converted to a 3-ordinal scale with 3 criteria for cut-off points (-1: nasalance score -1, -1.5 and -2 SD lower than the mean; 0: nasalance score ±1 SD, ±1.5 and ±2 SD of the mean; and +1: nasalance score +1 SD, +1.5, and +2 SD greater than the mean).

Results: Correlations between screening perceptual assessment and nasalance scores were good to excellent. The percentage of agreement was good, the Kappa reliability was fair to moderate in passages of a mixture of oral and nasal consonants (My House) and devoid of nasal consonants (Laying Hen). A weak relationship was found for the nasal passage (Winter).

Conclusion: The relationship of speech assessments in the present study varied, as it depended on the different variables and analysis. To ensure a strong relationship, further prospective study is needed.

Keywords: Perceptual evaluation, Nasalance score, Cleft, Resonance disorders

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Certain speech characteristics are typical of speech of individuals with cleft palate and can usually be identified by subjective perceptual judgments, which is generally accepted and indeed recommended for speech evaluation for clefts because it is a simple, non-invasive, essential procedure for preliminary diagnosis and it agrees with objective measurements (moderate to strong)(1).

Velopharyngeal incompetence is perceived as resonance disorders and a common cleft speech characteristic in children with cleft palate (CP). Resonance disorders are identified perceptually by speech and language pathologists (SLPs) experienced in working with patients with CP. The perceptual reliability among professionals has variability but this improves with experience(2). In developing countries, where there is a shortage of SLPs and a lack of standard assessment protocol (e.g., Sri Lanka(3,4), Vietnam(5,6), Indonesia(7), Mexico(8,9), India(10), Indonesia(7), Thailand(11,12), Lao PDR(13,14), screening perceptual evaluation for resonance is urgently needed as an outcome measurement.

In the context of diagnosing resonance disorders, an important criterion for establishing the validity of a measurement technique is to determine to what extent these findings agree with the perceptual judgments of velopharyngeal function and oral-nasal resonance for speech. Nasometry is a common objective measurement frequently used in studies of CP speech. It measures acoustic resonance energy and produces nasalance scores. It is the ratio of acoustic nasal energy to acoustic nasal plus acoustic oral energy multiplied by 100. The relationship of nasometry to the perceptual evaluation of resonance in speakers with CP has not been studied extensively. The objective of this study was to determine the relationship between screening perceptual assessment for resonance disorders and nasalance scores using nasometry measurements.
Material and Method

Study design
A retrospective cross-sectional study was conducted at the Speech Clinic of Srinagarind Hospital, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand

Participants
Children with cleft palate with or without lip (CP ± L), registered with the project “Smart Smile and Good Speech” between June 2007 and September 2010.

Inclusion criteria
Children with cleft palate CP ± L.

Exclusion criteria
Children with CP ± L without data for screening perceptual assessments and/or nasalance scores.

The authors initially included 384 children with CP ± L but after the exclusions were applied, there were 115 children with CP ± L in the present study.

Outcomes
The main outcomes of the present study were an ordinal 3-point rating scale (-1 = hyponasality; 0 = normal; +1 = hypernasality) for screening perceptual assessment of resonance disorders and percentages of nasalance scores for finding relationships.

Resonance disorders
Screening perceptual assessment was estimated based on the perception of speech samples comprising nonsense syllables, Thai serial speech with high oral pressure consonants (counting from 1-20 and 40-50) with 4 simple sentences loaded with all of the consonants and 3 nasal sentences, by the principal investigator with 20 years experience in cleft palate.

Speech samples of screening perceptual assessment were
Hyponasality test: - Nonsense syllables: /pʰi pʰi
                      pʰi pʰi pʰi pʰi/
                      - Connected speech: Counting from 40 to 50 in Thai language, comprising high oral pressure sounds: /s/ and /i:/
                      Simple sentences: /me: sai muak du t’ee wee/
                        /pʰi: tʰan nai khu: muai pet kap nai/
                        /nai len rot fai leh hun yoon/ 
                        /tʰan khan tu:con pʰat lom yan bon to/

Hyponasality test: /ma ma mu: ma/
                    /muai mu: muai/
                    /ma: muai/

The screening perceptual rating included:
1 = hyponasality; 0 = normal;
+1 = hypernasality

Nasalance scores
Nasometry (Nasometer II 6450 Kaypentax) the objective measure of resonance was used as an indication of the average nasalance scores for 3 standard Thai passages, viz.: (1) My House-having a mixture of oral and nasal consonants; (2) Laying Hen-devoid of nasal consonants; and (3) Winter-full of nasal consonants. The respective means (SD) of the nasalance score for My House, Laying Hen and Winter among normal Thai children were 14.3 (+ 5.8), 35.6 (+ 5.9) and 51.1 (+ 6.4)(15).

In order to compare the reliability coefficients, the nasalance scores were converted to an ordinal 3-scale rating according to 3 criteria. The three cut-off criteria were the mean of the nasalance scores for normal children ± 1, 1.5 and 2 SD. Abnormality of the resonance scores was identified as:
-1 = hyponasality or nasalance scores -1, -1.5 and -2 SD lower than the mean nasalance scores;
0 = normal or nasalance scores were between mean nasalance scores ± 1, ± 1.5 and ± 2 SD;
+1 = hypernasality or nasalance scores were +1, +1.5 and +2 SD above the mean nasalance scores.

Statistic analyses
Spearman’s rank correlation test was used to analyze the relationship between screening perceptual assessment of resonance disorders and the percentage of nasalance scores (from the individuals).

The Cohen Kappa statistic of the tests was used to assess the reliability of the screening perceptual assessment for resonance disorders and the rating of nasalance scores themselves.

Results
The characteristics of the 115 subjects are presented in Table 1. The proportion of females to males was ~6 to 4.

The Spearman’s rank correlation test showed that the correlation coefficients between screening perceptual assessment of resonance disorders and the percentage of nasalance scores ranged from moderate to excellent (Table 2).

The percentage of agreement between screening perceptual assessment of resonance disorders and percentage of nasalance scores ranged from moderate to good while the Cohen’s Kappa
coefficients ranged between poor and moderate (Table 3).

### Discussion

Improving the correlation and reliability of auditory perceptual assessments of nasality, especially for hypernasality, is a challenge for speech and language pathologists, as it requires an objective assessment instrument. In order to increase the understanding of hypernasality and its assessment, different aspects of the evaluation of nasality of speech in children with CP need to be investigated.

The correlation coefficients determined in the current study for screening perceptual ratings of nasality and nasalance scores for My House and Laying Hen ranged from good to excellent (0.67-0.86) (Table 2). This result is similar to reports of reliability between 0.69 and 0.74\(^{16}\). A strong relationship was found between the perceptual ratings of hypernasality and nasalance scores for the My House and Laying Hen.

### Table 1. Demographic characteristics of children with CP + L

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>68</td>
<td>59.13</td>
</tr>
<tr>
<td>Male</td>
<td>47</td>
<td>40.87</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>100</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-2</td>
<td>18</td>
<td>15.65</td>
</tr>
<tr>
<td>2-4</td>
<td>28</td>
<td>24.35</td>
</tr>
<tr>
<td>4-7</td>
<td>20</td>
<td>17.39</td>
</tr>
<tr>
<td>7-15</td>
<td>31</td>
<td>26.96</td>
</tr>
<tr>
<td>15+</td>
<td>18</td>
<td>15.65</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>100</td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleft palate</td>
<td>18</td>
<td>15.65</td>
</tr>
<tr>
<td>Left cleft lip and palate</td>
<td>38</td>
<td>33.04</td>
</tr>
<tr>
<td>Right cleft lip and palate</td>
<td>18</td>
<td>15.65</td>
</tr>
<tr>
<td>Bilateral cleft lip and palate</td>
<td>41</td>
<td>35.65</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 2. Correlation of screening perceptual assessment of resonance disorders and percentage of nasalance scores

<table>
<thead>
<tr>
<th>Variable</th>
<th>My house</th>
<th>Winter</th>
<th>Laying Hen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual Assessment</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>My house</td>
<td>0.68</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>Winter</td>
<td>0.48</td>
<td>0.84</td>
<td>1.00</td>
</tr>
<tr>
<td>Laying Hen</td>
<td>0.68</td>
<td>0.86</td>
<td>0.67</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3. Percentage of agreement and Cohen’s Kappa coefficients vis-à-vis perceptual assessment of resonance disorders and percentage of nasalance scores

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Percentage of agreement</th>
<th>Cohen’s Kappa coefficients</th>
<th>Standard Errors</th>
<th>Z</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>My house</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± 1.0 SD</td>
<td>70.43</td>
<td>0.42</td>
<td>0.08</td>
<td>5.30</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Mean ± 1.5 SD</td>
<td>73.04</td>
<td>0.48</td>
<td>0.08</td>
<td>5.79</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Mean ± 2.0 SD</td>
<td>76.52</td>
<td>0.56</td>
<td>0.08</td>
<td>6.76</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± 1.0 SD</td>
<td>50.43</td>
<td>0.20</td>
<td>0.06</td>
<td>3.11</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Mean ± 1.5 SD</td>
<td>48.71</td>
<td>0.19</td>
<td>0.06</td>
<td>3.27</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Mean ± 2.0 SD</td>
<td>40.88</td>
<td>0.09</td>
<td>0.05</td>
<td>1.75</td>
<td>0.04</td>
</tr>
<tr>
<td>Laying Hen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± 1.0 SD</td>
<td>69.57</td>
<td>0.35</td>
<td>0.07</td>
<td>5.01</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Mean ± 1.5 SD</td>
<td>71.30</td>
<td>0.38</td>
<td>0.077</td>
<td>5.12</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Mean ± 2.0 SD</td>
<td>74.78</td>
<td>0.46</td>
<td>0.08</td>
<td>5.93</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>
Hen passages but a weak relationship for the passages containing nasal consonants confirming the results of a previous study\(^1\). This observation might be the result of loading different contexts i.e., which effectively are sounds in the passage. The reason why Winter had a low relationship to the perceptual assessment might be because Winter has mostly nasal sounds that are minor sounds in normal Thai conversation\(^15\); whereas My House, like the Rainbow passage, has a mixture of oral and nasal consonants and Laying Hen, like the Zoo Passage, is devoid of nasal consonants. Auditory perception of nasalance scores from the My House and Laying Hen passages for detecting hypernasality might therefore be more sensitive than those from the nasalance scores of the Winter passage, which is the ostensible goal for detection hyponasality.

The percentage of agreement between hypernasality perceptual assessment and nasalance scores with three criteria were high or good vis-a-vis nasalance scores for the My House and Laying Hen passages were (69.57-67.52) (Table 3) and moderate for the passage Winter. The weighted kappa measurement had a moderate correlation between percentage of agreement vis-a-vis hypernasality perceptual assessment and nasalance scores for the My House and Laying Hen passages but low for the Winter (nasal) passage. The kappa measure for reliability is a conservative measure in that it assumes that any agreement that could have been obtained by chance was\(^17\); therefore, the kappa measure for reliability was chosen for determination the correlation beyond chance in the present study. Unlike a previous study\(^18\) that found the reliability was acceptable (Kappa’s coefficients range, 0.63 to 0.84), the Kappa’s coefficients in the current study represented only fair to moderate reliability (range, 0.35-0.56) vis-a-vis hypernasality perceptual assessment and nasalance scores for the My House and Laying Hen passages but were poor (range, 0.09-0.20) for the Winter passage. There was good reliability for the three criterion with a 2-SD cut-off with regard to the nasalance scores for My House and Laying Hen passages. This suggested that the criterion with + 2 SDs might be appropriate for clinical interpretation. The reliability of speech assessments, perceptual assessment and nasalance scores in the present study varied, as they depended upon different variables and types of analysis. Constructed speech samples and development in the reliability of perceptual ratings of speech and objective measures of nasalance scores need further prospective study.

**Conclusion**

The reliability of speech assessments in the study varied, as they depended upon different variables and types of analysis. Constructed speech samples and development in the reliability of perceptual ratings of speech and objective measures of nasalance scores need further prospective study.

**Acknowledgement**

Researchers wish to thank (a) the patients and their families for their trust and cooperation (b) the Faculty of Medicine, Khon Kaen University for its support (c) the Center of Cleft lip Cleft Palate and Craniofacial Deformities, Khon Kaen University, in association with the Tawanchai Project for publication arrangements and (d) Mr. Bryan Roderick Hamman and Mrs. Janice Loewen-Hamman for assistance with the English-language presentation of the manuscript.

**Potential conflicts of interest**

None.

**References**


ความสัมพันธ์ของการประเมินด้วยการฟังความผิดปกติของการสั่นพ้องของเสียงกับคะแนนสัดส่วนพลังงานเสียงที่ออกทางจมูกและปากของเด็กปากเพดานโหว่

เบญจมาศ พระธานี, ทวิตรี ภูมินำ, ชลดา สีพั้วฮาม

วัตถุประสงค์: เพื่อหาความสัมพันธ์ของการประเมินด้วยการฟังแบบคัดกรองความผิดปกติของการสั่นพ้องของเสียงกับคะแนนสัดส่วนพลังงานเสียงที่ออกทางจมูกและปาก

วัสดุและวิธีการ: การประเมินคัดกรองด้วยการฟังแบบคัดกรองความผิดปกติของการสั่นพ้องของเสียงของเด็กเพดานโหว่ที่มีหรือไม่มีปากแหว่งจำนวน 115 คน ถูกนำมาศึกษาความสัมพันธ์กับคะแนนสัดส่วนพลังงานเสียงที่ออกทางจมูกและปาก การประเมินคัดกรองให้คะแนน 3 ระดับ (-1: เสียงขึ้นจมูกมากเกินไป; 0: ปกติ; +1: เสียงขึ้นจมูกน้อยเกินไป) ถูกแปลงเป็นคะแนนสัดส่วนพลังงานเสียงที่ออกทางจมูกและปาก จากการตรวจคัดกรองเพื่อวิเคราะห์ค่านัยน์ของแคบป้า (Kappa) คะแนนสัดส่วนพลังงานเสียงที่ออกทางจมูกและปากถูกแปลงเป็นคะแนน 3 ระดับโดย 3 เกณฑ์ (-1: คะแนนที่ต่ำกว่าค่าเฉลี่ย - ความเบี่ยงเบนมาตรฐาน 1 เท่า, 1.5 เท่าและ 2 เท่า, 0: คะแนนที่อยู่ระหว่างค่าเฉลี่ย ± ความเบี่ยงเบนมาตรฐาน 1 เท่า, 1.5 เท่าและ 2 เท่า; +1: คะแนนที่สูงกว่าค่าเฉลี่ย + ความเบี่ยงเบนมาตรฐาน 1 เท่า, 1.5 เท่าและ 2 เท่าตามลำดับ)

ผลการศึกษา: ความสัมพันธ์ของการประเมินคัดกรองด้วยการฟังแบบคัดกรองความผิดปกติของการสั่นพ้องและคะแนนสัดส่วนพลังงานเสียงที่ออกทางจมูกและปากมีค่ากับศักยภาพของแคบป้า ร้อยละของความสอดคล้องอยู่ในระดับดี ด้านความสัมพันธ์ของแบบคัดกรองระหว่างความผิดปกติข้อความที่ประกอบด้วยเสียงพยัญชนะที่ออกทางจมูก (บ้านของฉัน) และข้อความที่หลีกเลี่ยงเสียงนาสิก (ไก่ออกไข่) พบความสัมพันธ์ด้านในขอบข่ายเสียงนาสิก (ไก่ออกไข่)

สรุป: ความสัมพันธ์ของการประเมินการพูดในการศึกษาครั้งนี้มีค่าค่อนข้างแตกต่างกันขึ้นกับตัวแปรและการวิเคราะห์การศึกษาแบบปรากฏการณ์ในอนาคตเป็นสิ่งจำเป็น

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