CORRELATION BETWEEN CT SCAN FINDINGS AND DEGREE OF HYPERNASALITY IN VELOPHARYNGEAL INSUFFICIENCY PATIENTS

Yasmeen Mohamed Mostafa Hamza*, Hassan Hosny Ghandour**, Jilan Fouad Nassar**, and Dina Ahmed Elsayed Elrefaie**

ABSTRACT:

**Background:** Velopharyngeal Insufficiency (VPI) is the most common seen disorder in children with associated craniofacial developmental anomalies of which cleft palate is the most common. Overt cleft palate, in both before and after repair, is by far the most common cause of VPI. Computerized tomography (CT scan) is used to assess mobility of the velum, lateral and posterior pharyngeal walls, but it needs a cooperative patient (>5 years). Its advantages are the easy definition of measured parameters, the provision of automated numerical value regarding the size of velopharyngeal gap and the amount of displacement of each wall as well as the provision information about the vertical level of closure of the velopharyngeal port referring to surrounding structures.

**Aim of the work:** To analyze the CT findings and its correlation to severity of the hypernasality in velopharyngeal insufficiency patients.

**Patients and methods:** This study was applied on 50 patients with age ranging from 20 - 60 years, from January 2017 to December 2020, diagnosed hypernasality caused by velopharyngeal insufficiency, from the outpatient Phoniatric clinic at Ain Shams University Hospitals. Each patient was subjected to the following: 1- Auditory perceptual assessment (APA) to assess hypernasality presence and degrees. 2- Computed tomography (facial view) over the velopharyngeal valve to assess the valvular functions. To compare CT findings of the velopharyngeal port to the severity of the hypernasality in patients.

**Results:** It showed that mild degree hyper-nasality will be seen in CT as valve gap (while sustained vowel production) with mean of 1.914 mm gap ranging from (0.03 - 5.23 mm) in 17 cases. While moderate degree hyper-nasality showed CT valve gap with mean of 5.75 range from (2.05-10 mm) in 16 cases. Moderately severe hypernasality showed CT valve gap with mean of 7.09 range valve gap (3.45-11mm) in 12 cases. Severe degree hyper-nasality showed CT valve gap mean of 10.42 ranges from (7.05-13 mm) in 5 cases. The overlapping between ranges in different degrees of nasality was obvious.

**Conclusion:** The present study showed that CT scan measurement suggestive of severity in moderate to severe degrees of hypernasality more than mild and mild to moderate degrees.

**Keywords:** Hypernasality, Radiology, Velopharyngeal Insufficiency.
INTRODUCTION:

Velopharyngeal insufficiency (VPI) defined as incomplete closure of the velopharyngeal port during speech producing tasks that result in hyper-nasal speech, nasal air emission, compensatory misarticulating, lowered vocal intensity and facial grimacing (1).

Velopharyngeal incompetence is a common problem following the primary repair of cleft palate. A competent velopharyngeal mechanism is the goal in repair of soft palate (2).

The effect of VPI on speech and resonance ranges from mild speech distortion to catastrophic disruption of speech intelligibility, leading to breakdown of the ability to communicate verbally (3).

One of the most common causes of VPI is cleft palate even after being repaired. The frequency of hypernasality after cleft palate repair that may need secondary surgery varies in different literature between 15 and 45%. VPI occurs when the surgically repaired cleft palate is of inadequate mobility for elevation and achieving velopharyngeal closure and thus optimal speech, which is one of the primary goals of surgical repair (1).

Normal velopharyngeal closure is accomplished by the coordinated and perfectly timed actions of muscular parts of the velum, both lateral pharyngeal walls and the posterior pharyngeal wall. These structures are the ones who functions as a valve that serves to separate the nasal cavity from the oral cavity during speech as well as other functions as singing, blowing, swallowing, suckling, gagging and vomiting (4).

CT scan assess mobility of the velum, lateral and posterior pharyngeal walls, but it needs a cooperative patient (>5 years) (5). Its advantages are the easy definition of measured parameters, the provision of automated numerical value regarding the size of velopharyngeal gap and the amount of displacement of each wall as well as the provision information about the vertical level of closure of the velopharyngeal port referring to surrounding structures. On the other hand, it gives no information about the dynamic function during speech production. The effect of gravity in the supine position may alter the actual picture of velar function. Moreover, the amount of exposure of radiation cannot be overlooked (6).

The levator veli muscle help retract the velum (soft palate) to permit separation of the nasopharynx from the oropharynx by complete coverage of the soft palate against the posterior pharyngeal wall. Patients with cleft palate have abnormalities of the levator veli palatini muscle, resulting in suboptimal velopharyngeal closure, known as VPI. This causes hypernasality that impairs speech development. Nasoendoscopy and videofluoroscopy were used to assess velopharyngeal anatomy. However, nasoendoscopy is invasive as it involves placement of an endoscope into the pharyngeal region and may cause patient anxiety and discomfort, especially in children. In addition, videofluoroscopy, as with other fluoroscopic studies, has inherent measurement errors that may vary with patient positioning (7). With the advances in cross-sectional imaging modalities including (CT) and magnetic resonance imaging (MRI), non-invasive radiological tool to assess bony anatomy and velopharyngeal musculature with easily reproducible anatomy and measurements is now feasible. Preoperative imaging assessment assists pediatric and maxillofacial dental surgeons in surgical interventions.

AIM OF THE WORK

To analyze the CT findings and its correlation to severity of the hypernasality in velopharyngeal insufficiency patients.
PATIENTS AND METHODS

Patients:

50 hypernasality patients caused by VPI, recruited from the outpatient Phoniatric clinic at Ain Shams University Hospitals from January 2017 to December 2020, were included in this study.

Selection criteria:

Inclusion criteria:

• Abnormal resonance (opened) judged by Auditory Perceptual Assessment and clinically diagnosed as VPI.
• Native Arabic speakers.

Exclusion criteria:

• Age (below 20 years or above 60 years).
• Patients with respiratory tract infections on the day of examination.
• History of hearing impairment, mental retardation, Neuropsychiatric problems, or allergy.
• Comprehensive language deficits.

The study was conducted in accordance with the ethical standards in the Faculty of Medicine, Ain Shams University, with the prior written consent of the patients.

Methods:

All patients underwent the following steps of the speech protocol:

Patient interview:

➢ Personal Data: name, age and gender, education, occupation, residence, marital status and number of children / Complaint and analysis of symptoms: Duration - onset – course

➢ Subjective perceptual assessments of patients: using APA detect severity of hypernasality as 4 Grading system (0= normal resonance, 1=mild hypernasality, 2=moderate hypernasality, 3=moderate to severe hypernasality,4= severe hypernasality.

Visual examination of vocal tract:

By using the simple clinical examination tools for reporting on lips, palate morphology and mobility, the mobility of pharyngeal walls, tonsils size, nose, ear examination and laryngeal examination

Radiological Studies: through computed tomography (CT):

It is done by utilizing a computer tomography with a slicing width 3 mm. The plane of tomography is at the extent between the nasolabial angle and therefore the lower margin of the ear lobe. stills are taken at rest and through sustained /a/ vowel, the sagittal and therefore the coronal dimensions are measured. The velopharyngeal port area is calculated both at rest and through sustained phonation. CT as a feasible non-invasive objective procedure for measurement of the velopharyngeal port area and therefore the amount of displacement of the components of the port in one picture. The calculated parameters were easily defined, the supply of automated numerical values regarding the dimensions of the velopharyngeal port and therefore the amount of displacement of every wall up reference to surrounding structures are all possible, it allows visualization of various structures in each dimension (width, depth and height)\(^{(8)}\)

Statistical Analysis

i. Descriptive statistics:

1. Mean ± SD (standard deviation) and Range for parametric numerical data. Median and Interquartile range (IQR) for non-parametric numerical data.

2. Frequency/Number and Percentage of non-numerical data.

ii. Analytical statistics:
**Paired t-test** was used to assess the statistical significance of the difference between two means measured twice for the same study group.

The distribution of age and gender of the participated Hypernasal tone of speech patients of 21 male cases (42%) and 29 female patients (58%) showed in **Table 1 and Table 2**.

**RESULTS**

Table 1: The distribution of the sex among hypernasality patients

<table>
<thead>
<tr>
<th>Sex</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>21</td>
<td>42%</td>
</tr>
<tr>
<td>Female</td>
<td>29</td>
<td>58%</td>
</tr>
</tbody>
</table>

Table 2: mean of age

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.12 ± 10.47</td>
<td>21 - 59</td>
<td></td>
</tr>
</tbody>
</table>

CT scan (facial view) was done to all patients to detect radiological velopharyngeal gap space in mm. It showed that mild degree hyper-nasality will be seen in CT as valve gap (while sustained vowel production) with mean of 1.914 mm gap ranging from (0.03 -5.23 mm) in 17 cases.

While moderate degree hyper-nasality showed CT valve gap with mean of 5.75 range from (2.05-10 mm) in 16 cases.

Moderate severe hyper nasality showed CT valve gap with mean of 7.09 range valve gap (3.45-11mm) in 12 cases. Severe degree hyper-nasality showed CT valve gap mean of 10.42 range from (7.05-13 mm) in 5 cases. The overlapping between ranges in different degrees of nasality was obvious.as shown in **Table 3**.

CT Finding is a statistically significant predictor of the severity of nasality.

Table (3): CT scan findings in comparison to grade of hypernasality

<table>
<thead>
<tr>
<th>HYPER-NASALITY</th>
<th>Count</th>
<th>MEAN</th>
<th>S.D.</th>
<th>Median</th>
<th>Minim.</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild hyper nasality</td>
<td>17</td>
<td>1.9147</td>
<td>1.48899</td>
<td>1.6</td>
<td>0.03</td>
<td>5.23</td>
</tr>
<tr>
<td>Moderate hyper nasality</td>
<td>16</td>
<td>5.7531</td>
<td>2.76262</td>
<td>5.31</td>
<td>2.05</td>
<td>10</td>
</tr>
<tr>
<td>Moderate to severe hypernasality</td>
<td>12</td>
<td>7.0933</td>
<td>2.48720</td>
<td>7.1150</td>
<td>3.45</td>
<td>11</td>
</tr>
<tr>
<td>Severe hypernasality</td>
<td>5</td>
<td>10.4200</td>
<td>2.19523</td>
<td>10.44</td>
<td>7.05</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>5.2364</td>
<td>3.51338</td>
<td>4.2650</td>
<td>0.3</td>
<td>13.00</td>
</tr>
</tbody>
</table>

While correlating the APA findings to the CT scan results was found as statically significant as shown in **Table 4**.

Table (4): CT scan in comparison to PWSS results

<table>
<thead>
<tr>
<th>APA</th>
<th>Number of cases</th>
<th>MEAN</th>
<th>SD</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>borderline competent VPV</td>
<td>5</td>
<td>0.7620</td>
<td>0.49952</td>
<td>0.9800</td>
<td>0.03</td>
<td>1.30</td>
</tr>
<tr>
<td>borderline incompetent VPV</td>
<td>14</td>
<td>2.9107</td>
<td>2.18263</td>
<td>1.9500</td>
<td>0.90</td>
<td>8.70</td>
</tr>
<tr>
<td>Incompetent VPV</td>
<td>31</td>
<td>7.0084</td>
<td>2.99</td>
<td>7.0500</td>
<td>2.05</td>
<td>13.00</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>5.2364</td>
<td>3.51</td>
<td>4.2650</td>
<td>0.3</td>
<td>13.00</td>
</tr>
</tbody>
</table>
DISCUSSION;

The purpose of this study was to evaluate the changes to the velopharyngeal anatomy using CT scans. In addition, the differences in these measures between patients and the correlation between velopharyngeal gap size and severity of auditory perceived hypernasality.

In this study, 50 hypernasality patients underwent the clinical assessment and CT scan. On perceptual analysis of patients, 6 were auditory perceived in APA as mild hypernasality, 24 cases were auditorily perceived as moderate hypernasality, 18 patients were found as moderately severe hypernasality and 2 patients as severe hypernasality.

In previous studies CT scan of VPV and nasoendoscopy were used as the objective evaluation of velopharyngeal closure. In patients with cleft palates, CT scans of the velopharynx were made both at rest and through vowel phonation with a scanning time of three seconds and slicing width of 3 mm. At an equivalent time, endoscopic observations of the velopharynx through the nose were administered both at rest and through phonation. CT scan during phonation clearly demonstrated the mobility of the velopharynx, i.e., elevation of the soft palate and medial movement of the lateral pharyngeal walls during a single picture. Its disadvantage is exposure to x-rays and expensive time and resources consuming procedure.

Limitations faced during applying CT scan for hypernasality patients
1. lack of experienced physician and technicians who concerned with VPV area visualization.
2. limited benefits out of imaging rather than research as it doesn’t add to other clinical and instrumental measures to decide the treatment and intervention required.
3. 3-Patient position and degree of stability during imaging at phonation and the slice or cut taken for measurement is the maximum closure which can be subjectively changed according to technicians and age and sex differences
4. plastic surgeons usually use MRI for postoperative follow up and Naso-fibroscopic examination for direct visualization and more acceptable than repeated imaging with less cost and better accessibility for patients and across different cities and hospitals
5. 5-Lack of clear demarcation between different grades of VPI, As we found overlapping of size of gap during phonation that cannot be relied on alone to decide live of treatment especially invasive or surgery without direct visualization and clinical examination of valve functions during both phonation and swallowing functions.

Conclusion & Recommendations:

CT scan can be considered as a good predictor and pre-operative investigations but it can be replaced with other nasality workouts of clinical examination and direct visualization of the velopharyngeal area in patients from 20-60 years old patients.

Further work needs to be done on Larger-scale to compare the CT findings and standardization in hypernasality patients.

REFERENCES


نتائج التصوير المقطعي في مرضى فرط الخف التنموي عن فصور الصمام اللثائي البلعومي

ياسمين عبد مصطفى حمزة، أ.د.حسن حسن غدورة، أ.د.جبلان نصار **

السيد الرفاعي **

المقدمة:
لا تقتصر الوظائف العصبية والعضلية المعدة التي تنظم كلام الإنسان على الحجرة حيث يلعب احكام
إغلاق الصمام اللثائي البلعومي دورا هاما في إصدار أصوات السواكن والمتحركات مما يؤثر على درجة وضوح
الكلام. عدم كفاءة الصمام اللثائي البلعومي في الحالة التي تؤدي إلى زيادة النزف النفلي وتشويه الابتعادات الأنفية أثناء
الكلام. ويرجع ذلك إلى عدم الفعالية الهيكليه للتغطية والتغطية البلعوم الأنفي في الحركات المفصلية المتصلة السريعة
التي يتم تزويدها بشكل صحيح مع غيرها من آلة النطق.

ضعف أو عدم كفاءة وظيفة الصمام اللثائي البلعومي يمكن أن يحدث بسبب مجموعة متنوعة من الأسباب. يمكن أن
يكون راجعا إلى خلل تشريحي أو هيكلي عادة ما يشار إلى فجوات في البلعوم، أو اضطراب فسيولوجي بسبب ضعف حركة
البلعوم، وعادة ما يسمى الفجوات بين البلعوم. كما يمكن أن يكون أيضا بسبب قصور في إكتساب الكلام، مما أدى إلى
استخدام أعداء خطأ لإغلاق الصمام.

هدف الدراسة: يهدف هذا العمل إلى تحليل نتائج التصوير المقطعي وارتفاعها مع=postfix-or-markdown
asuring عن فصول الصمام اللثائي البلعومي.

المريض وطريق البحث:

المريض: اجتمعت هذه الدراسة على خمسين مريضاً يعانون من فجوات في الصمام اللثائي البلعومي، الذين تم إجراء
هم عدداً من الكاسحات على إعادة التخطيط في مستشفى جامعة عين شمس.

المعايير الاستعمال هي: رنين غير طبيعي (مفترض) يحكم عليه التشخيص الإدراكي السعدي وتشخيصه إكليتيكياً على أنه
فرط خف.

النتائج: النتائج تشير إلى أن فجوات في الصمام اللثائي البلعومي يمكن أن يكوناً

الخلاصات: ادى فجوات في الصمام اللثائي البلعومي إلى اضطراب في إكتساب الكلام، مما يمكن
تغطيه مع جابور من الفجوات المفتوح في عيوب خف المفتوح (زيادة النزف النفلي).

• مقياس الرنين الأذني هو أسلوب الأكثر استخداماً على نطاق واسع لتنقيح الصمت للكلام.
• تم إجراء الدراسة وفقاً للمعايير الأخلاقية المنصوص عليها في كلية الطب جامعة عين شمس، مع الحصول على
• موافقة مكتوبة مسبقة من المرضى.

ملاحظات:

-оборب ظبط انشأت هذا الدراسة على خمسين مريضاً يعانون من فجوات في الصمام اللثائي البلعومي، الذين تم إجراء
هم عدداً من الكاسحات على إعادة التخطيط في مستشفى جامعة عين شمس.

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-ملاحظات: