Comparison of sensitivity and specificity of mirror test and cephalometry in assessing velopharyngeal insufficiency after reconstruction of cleft palate

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Abstract. The velopharyngeal valve has an important role in controlling the flow of air during speech and incomplete velopharyngeal closure causes problems with speech. There are several modalities to assess velopharyngeal insufficiency, including using the mirror test and cephalometric radiographs. This study aimed to determine the sensitivity and specificity of the mirror test and cephalometric radiography for velopharyngeal insufficiency examination in patients after cleft palate reconstruction. A cross-sectional analytic study with a specific design for a diagnostic test was conducted. Data was grouped in a 2 × 2 table using the gold standard endoscopic examination. Data was obtained from patients aged 5–11 years after reconstruction of cleft palate and speech therapy in the SEHATI Program at Children and Maternal Hospital Harapan Kita Jakarta. Cephalometric radiographs had a higher sensitivity (100%) but lower specificity (33.3%) compared to the mirror test. The false-negative rate of cephalometric radiographs was 66.66%. Cephalometric radiographs have a higher sensitivity than the mirror test (the initial method of examination method) and can be used for velopharyngeal insufficiency examination along with the mirror test.

1. Introduction
The velopharyngeal valve has an important role in controlling airflow during speech [1,2]. Velopharyngeal dysfunction is the condition in which the velopharyngeal valve is unable to close perfectly, causing air flow into the nasal cavity during speech. Velopharyngeal dysfunction also includes velopharyngeal insufficiency (due to a structural or anatomical defect of the velopharyngeal organ), velopharyngeal incompetence (neurological disorder causing velopharyngeal organ interference), and velopharyngeal mislearning (pattern of compensatory articulation as result of an inappropriate velopharyngeal valve closure pattern) [3,4].

To overcome the speech problems caused by imperfect velopharyngeal valve closure, it is necessary to reconstruct the cleft palate surgically. Palatoplasty is intended to achieve anatomical and functional closure of the normal hard and soft palates, and is expected to improve soft palate function as part of the velopharyngeal system [5]. The ability to speak clearly to communicate and potentially improve the patient’s social life is a goal of this cleft palate reconstruction. However, postoperative
complications include the emergence of nasal secretions. Therefore, a thorough examination of all velopharyngeal valve components is necessary. Some investigators classify the examination procedures based on instrumentation use, while others do so based on visualization at the time of examination. Kuehn classified the procedures for velopharyngeal function examination as noninstrumental, such as the mirror test, and instrumental, such as cephalometry, nasoendoscopy, and videofluoroscopy [6].

The mirror test uses a scaled plate to detect the presence of air escaping from the nasal cavity during speech. This modality can be used in children and adults, as well as patients with intellectual disabilities [7].

The use of cephalometric radiographs to assess velopharyngeal function was first published in 1909. Despite two-dimensional imaging, it was the gold standard of velopharyngeal functional assessment in its time until the discovery of nasal endoscopy [8].

We compared the sensitivity and specificity of the mirror test and cephalometric radiography in detecting the presence of a velopharyngeal gap after reconstruction of cleft palate via the pushback palatoplasty technique with modified Z-Plasty at Children and Maternal Hospital Harapan Kita Jakarta.

2. Methods
A retrospective study with a cross-sectional design was done on the results of nasal secretion measurement using the mirror test, cephalometric radiography, and nasoendoscopy in patients five to 11 years old, who had undergone cleft palate reconstruction with subsequent speech therapy as the treatment plan in the Cleft Lip and Palate Unit of Children and Maternal Hospital Harapan Kita. The study was performed between June and July 2014.

Inclusion criteria were: male or female patients aged five to 11 years with nonsyndromic complete cleft palate who had undergone cleft palate reconstruction with subsequent speech therapy and had undergone pushback Z-Plasty technique on the nasal mucosa at 1.5 years old with subsequent speech therapy, no oronasal fistula after cleft palate reconstruction and patient in good health during the nasoendoscopy examination. Exclusion criteria were: submucous cleft palate, patient underwent repeat pushback palatoplasty, and use of speech devices.

Data was collected from the patient list book for patients treated at our hospital between 2006 and 2007. The data was classified according to patient age at cleft palate reconstruction. Then, simple random sampling was performed to obtain the total number of research subjects required. Based on the randomization results, patients were called in and the patient’s family provided written informed consent for participation in the study. All patients were examined using the mirror test, cephalometric radiography, and endoscopy. Figure 1 shows cephalometric landmarks used in this study.

Figure 1. Cephalometric landmarks used in this study: N (nasion), the most anterior point between the os frontal and os; S (sella), center point of the sella turcica; PPW, point where the extension of the palatal plane intersects the posterior wall of the pharynx; VPCs, superior point from the velopharyngeal contact; VPCm, middle point from the velopharyngeal contact; VPCI, inferior point from velopharyngeal the contact [9].
The results of this special design study for diagnostic tests were grouped in a 2 × 2 table (Table 1). The sensitivity, specificity, positive and negative predictive values, prevalence, and positive and negative possibility ratios based on cross tabulation result from two examinations were determined according to first (Examination I) and second (Examination II) examination results. The first examination was performed using the mirror test or cephalometric radiography, while the second examination was performed using the gold standard nasoendoscopy, which is the direct examination to visualize or assess velopharyngeal function. [8].

### Table 1. Examination I (nasoendoscopy).

| Test Result | Mirror Test | Cephalometry |
|-------------|-------------|--------------|
| Sensitivity | 0%          | 100%         |
| Specificity | 100%        | 33.3%        |
| Positive predictive value | 0% | 77.7% |
| Negative predictive value | 30% | 100% |
| Prevalence | 70%         | 70%          |
| Positive possibility ratio | 0 | 3.09 |
| Negative possibility ratio | 1 | 0 |

### 3. Results

The subject distribution based on patient diagnosis was nearly equal: five patients (50%) had unilateral cleft palate (CLP), while four (40%) had unilateral (UCLP) and one (10%) had bilateral (BCLP) cleft lip and palate. Most patients (90%) were male. The average patient age was 8.1 years (range, 5–11 years).

Examination modality (mirror test vs. cephalometry) was compared to determine the best modality, based on a 2 × 2 table comparison of the statistical results (Table 2).

### 4. Discussion

The main goal of cleft palate management is clear speech. However, such management does not always obtain the expected results. Speech impairment is a result of air escaping into the nasal cavity during speech and is caused by velopharyngeal insufficiency. Clinical features of velopharyngeal insufficiency are characterized by the emergence of hypernasality and nasal secretions [7].
Velopharyngeal insufficiency can occur in different conditions either pre- or postoperatively. Several complications of cleft palate management include a shorter velum, limited velum movement, and oronasal fistula. Jones et al. classified velopharyngeal insufficiency into two types, namely “Almost but Not Quite” and “Sometimes but Not Always” [10]. Speech therapy based on the severity of velopharyngeal insufficiency is not recommended. It is recommended to examine the anatomy and function of the velopharyngeal valve causing the velopharyngeal insufficiency [2,7,10].

Decisions on establishing the diagnosis of velopharyngeal insufficiency based on anamnesis, perceptual assessment, and physical and supported examination are important. It is recommended to conduct some assessment modalities so that misdiagnosis can be avoided and an appropriate subsequent treatment plan can be determined [11,12].

In general, velopharyngeal assessment procedures are divided into two categories: direct (noninstrument assessment) and direct (instrumented assessment, including cephalometric radiography, videofluoroscopy, and nasoendoscopy) [2,6]. We examined velopharyngeal function using two modalities: the mirror test and cephalometric radiography. The mirror test is an easy-to-use method for children, adults, and intellectually disabled patients. However, Ogata et al. recommended using the nasometer and blowing test ratio to confirm the accuracy of the mirror test [7].

Our results indicated absence of nasal secretions in all patients. Thus, based on the mirror test, all patients were considered to have good velopharyngeal function. Meanwhile, different results were found on cephalometric radiography examination; only 12 patients (10%) had good velopharyngeal function according to nasoendoscopy.

According to the compensatory articulation theory, maladaptive articulation is a condition where the tongue moves over the gap to prevent air entering the nasal cavity during speech. Speech therapy can improve velopharyngeal function in cases of minimal velopharyngeal insufficiency. After cleft palate reconstruction, patients begin speech therapy to eliminate or reduce hypernasality, so that they are able to communicate well verbally. The first exercise in a speech therapy session is velum exercise, aiming to maximize muscle function of the velum. Then, nasality exercise aims at maximizing the velopharyngeal component, thus reducing nasal air escape and hypernasality [4,5].

In our study, the sensitivity of cephalometric radiography was higher (100%) than that of the study of Rubinsky and Eslava-Schmalbach (86.3%) [13]. However, specificity of cephalometric was lower in our study (33.3% vs. 75%) [13].

Our study has certain limitations. The total number of subjects was not according to the planned amount. This was due to the facts that the subjects consisted of purposive samples that were limited by exclusion and inclusion criteria (subjects must have followed the cleft palate treatment plan procedure at our hospital), some parents refused nasoendoscopic examination, in some cases cephalometry examination and nasoendoscopy had not yet been included in the treatment protocol at our hospital, equipment was limited, and the parents of a school-aged patient were worried about disruption of the learning process. Therefore, a larger study population is needed to provide a better image of velopharyngeal insufficiency examination procedures.

5. Conclusion
Cephalometric radiography had a higher sensitivity than the mirror test. For this reason, cephalometric radiography may be used for velopharyngeal insufficiency examination along with the mirror test, which is initial modality for velopharyngeal insufficiency examination.

6. References
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