The Smile Index: Part 3. A Simple, Prognostic Severity Scale for Unilateral Cleft Palate

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Background: Unilateral cleft palates have a large spectrum of variability. Key morphologic factors such as cleft width and palatal length are not represented in current classification systems. Palate length and velopharyngeal port size are clinically linked to speech outcomes, as the soft palate must close the posterior pharynx for proper phonation. This study investigates the relationship between objective preoperative measures and postoperative velopharyngeal port size, to define a reproducible severity scale.

Methods: Surgical data were prospectively collected from unilateral cleft palate patients in Morocco, Bolivia, Vietnam, and Madagascar. Key measurements were cleft width and palate width at the hard–soft palate junction, alveolar cleft width, vertical alveolar discrepancy, velopharyngeal port size. Cleft width ratio (CWR) was defined as the width of the cleft at the hard–soft junction, divided by the palate width.

Results: Seventy-six patients were evaluated. Thirty-one had complete clefts and average age at surgical repair was 2.9 years. Mean CWR was 0.50 ± 0.12. Palate length was increased by an average of 2.2 mm (11%) after palatoplasty. Multivariate analysis determined greater CWR and larger preoperative velopharyngeal ports were significantly correlated with a smaller percent change in palate length after palatoplasty (P < 0.01).

Conclusions: A wider palatal cleft decreases the surgeon’s ability to decrease velopharyngeal port size through palatoplasty. Given the ease of measurement even in low-resource settings, CWR may be a valuable tool for setting expectations for speech results, modifying surgical technique, and correlating future speech outcomes in evidence-based cleft care. (Plast Reconstr Surg Glob Open 2021;9:e3870; doi: 10.1097/GOX.0000000000003870; Published online 22 October 2021.)
for the American Cleft Palate and Craniofacial Association (Fig. 1C). The systems above describe the location of a cleft but fail to address two aspects of disease morphology that have important implications for surgical success and future speech outcomes: cleft width and palate length. Bardach defined a “wide” cleft palate as a palatal gap greater than 1.5 cm, whereas others describe an “extremely wide” cleft as a defect larger than the width of both palatal shelves. Multiple studies have correlated wider clefts with increased rates of postpalatoplasty fistula and velopharyngeal insufficiency. Lengthening the soft palate through palatoplasty decreases the velopharyngeal port size, and is critical for allowing closure of the posterior pharynx and normal phonation. Randall et al demonstrated that patients with longer palates (smaller velopharyngeal ports) postoperatively had better speech outcomes.

The low incidence of cleft disease, variable treatment algorithms, and barriers to long-term follow-up make large-scale studies difficult. Recording objective phenotypic data before and after surgery is challenging, given the lack of a standardized severity scale. Consistent and easy to record measurements would mitigate obstacles for analytic research in cleft palate. Our previous work (“The Smile Index” Part 1 and Part 2) identified universal and reproducible measurements for unilateral cleft lip that correlated with clinical outcomes. We aim to similarly guide surgical expectations and surgical technique selection in unilateral cleft palate by recommending objective measures that represent disease severity.

**METHODS**

This prospective study includes all children with unilateral cleft through the hard and soft palate (with or without cleft lip) who received a primary palatoplasty at Operation Smile surgical mission sites in Hanoi, Vietnam (November 2014), Santa Cruz, Bolivia (March 2015), Dakhla, Morocco (April 2015), and Antananarivo, Madagascar (April 2015). Locations were chosen based on geographic and ethnic diversity. Operation Smile is an international not-for-profit organization that offers free surgical treatment for cleft lip and palate. This study was approved by the institutional review board of the University of Southern California and Operation Smile International.

Demographic, photographic, physical examination, and surgical data were recorded using an encrypted iPhone application designed for this study. (See figure, Supplemental Digital Content 1, which displays the screenshots from the iPhone application developed for this study, used to collect measurements for (a) palate width and cleft width ratio (CWR), and (b) velopharyngeal port size. [http://links.lww.com/PRSGO/B806](http://links.lww.com/PRSGO/B806).) Figure 2 details the landmarks, measurements, and ratios documented for each patient preoperatively and postoperatively. Metrics were chosen from the related literature by Noordhoff, Bardach, Landheer et al, Rossel-Perry et al, and Phua and de Chalain. Linear distances were measured by the first author, a pediatric plastic surgeon specializing in cleft surgery, using a caliper to the nearest 0.5 mm. CWR was defined as the width of the cleft at the hard–soft junction, divided by the full palate width (Fig. 2A). Alveolar discrepancy was the vertical distance between the inferior-most aspect of the greater and lesser segment (Fig. 2C). Velopharyngeal port size was defined as the distance from the tip of uvula to the posterior pharynx. This was measured using a depth gauge with the patient supine and a Dingman retractor in place. Velopharyngeal port size was used to infer palate
length. Figure 2D demonstrates how the size of anterolateral mucosal gaps was measured.

RESULTS

We examined 76 patients with unilateral cleft palate from four countries: Bolivia (n = 15), Vietnam (n = 35), Morocco (n = 8), and Madagascar (n = 28). Fifty-four cleft palates were left-sided and 31 were complete. The majority had cleft lip and palate (n = 57), whereas 19 patients had isolated cleft palate. Average age at palatoplasty was 2.9 years (range 10 months–11 years) with an average weight of 12.0 kg. Cleft palate repairs were done by 13 different surgeons, who all used variations of a two-flap palatoplasty technique with islandization. In this approach, mucoperiosteal flaps are raised based on the greater palatine neurovascular bundles, elevating the flaps from the hard palate and the muscle attached to the posterior edge of it, providing significant mobilization toward midline. The two flaps are then pushed back, leaving a raw area anteriorly and laterally. Surgeon experience ranged from 1 to 25 years of posttraining practice, with a mean of 12 years of experience.

Mean and median CWR were $0.50 \pm 0.12$ and 0.48, respectively. The distribution of CWR was skewed to the right (Fig. 3). Velopharyngeal port size (distance from the tip of uvula to the posterior pharynx) had a preoperative mean of 14.4 mm ± 4.0 mm and a postoperative mean of $12.2 \text{ mm} \pm 3.6 \text{ mm}$ ($P < 0.01$, paired t-test), representing an average palatal length increase of 2.2 mm (11%, range $-3$ to 12 mm). The palate was lengthened in 57 cases (75%).

Mean CWR at the alveolus (width of the alveolar cleft divided by the width of the palate) was 0.07 ± 0.06. Univariate analysis showed no significant correlation between the change in velopharyngeal port size and the following variables: patient weight, surgeon experience, cleft laterality, alveolar cleft width, and postoperative anterolateral mucosal gap (Table 1). Preoperative velopharyngeal port size and postoperative mucosal gap (cumulative) were not significantly correlated ($R^2 = 0.2, P = 0.21$). Smaller velopharyngeal port size (longer palate) after surgery significantly correlated with smaller CWR.
TABLE 1. Univariate Analysis of Patient and Cleft Characteristics Associated with Decreased Postoperative Velopharyngeal Port Size

| Characteristic                | Coefficient | 95% CI      | P       |
|------------------------------|-------------|-------------|---------|
| Weight (kg)                  | 0.016       | −0.19 to 0.23 | 0.88    |
| Surgeon experience           | 0.94        | −3.48 to 2.68 | 0.29    |
| Cleft laterality (right)     | 0.012       | −1.83 to 1.86 | 0.99    |
| CWR                          | −24.42      | −40.58 to −8.26 | 0.004  |
| Alveolar height discrepancy  | 2.00        | 3.21 to 0.79  | <0.01   |
| Preoperative velopharyngeal  | 0.47        | 0.29 to 0.64  | <0.01   |
| port size                    |             |             |         |
| Postoperative mucosal gap    | 0.096       | −0.041 to 0.23 | 0.17    |

Bold values indicate variables that were significant (P < 0.05).
FIG. 4. Greater reduction in velopharyngeal port size after cleft palate repair was significantly correlated with lower CWR.

FIG. 5. Reduction in velopharyngeal port size after cleft palate repair was significantly correlated with smaller preoperative velopharyngeal port (longer palate length).
typical single-surgeon cleft studies. A larger study popu-
lization from a greater number of countries would ensure
widely generalizable results. Although hand measure-
ments have an element of error, our measurements were
more consistent because they were taken by the same sur-
geon. Most surgeons make personal modifications to the
two-flap technique, making surgical technique consistency
a limitation. Our results may not be applicable to palato-
plasty techniques other than the two-flap, such as Furlow.
Additionally, surgeons may have different anatomical goals
of palatoplasty; although some prioritize lengthening the
palate for speech improvement, others prioritize mini-
mal dissection to prevent scarring. Lack of longitudinal
follow-up made it impossible to track fistula rates, speech
development, or other complications. Without long-term
speech data, we could not validate velopharyngeal port
size as our outcome of interest. International cohorts from
surgical missions are inherently limited in longitudinal
follow-up due to a lack of resources. Extending this study
to children’s hospitals in the United States could deter-
mine whether immediate postoperative velopharyngeal
port size is related to long-term speech outcomes.

CONCLUSIONS
CWR is a scale for cleft palate disease severity that is
easily measured and affects the ability to lengthen the
palate through surgery. Although other factors such as
preoperative velopharyngeal port size, completeness of
cleft, and alveolar height discrepancy are also associated
with palate lengthening through palatoplasty, these vari-
ables tell an incomplete story. Current classification sys-
tems describe basic cleft anatomy, but do not account for
aspects of disease severity that surgeons intuitively identify.
CWR captures important prognostic aspects of morphol-
ogy and offers a simple metric that may be used in future
evidence-based studies of cleft palate.

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