Classification of Cleft Phenotypes

5

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> *The beginning of wisdom is to call things by their right name.*
> *Chinese proverb reference unknown.*

5.1 Classification of Cleft Phenotypes

Cleft is about to become a compulsory notification like other diseases in Brazil by a new law. Every child born with cleft must be reported and the exact number of newborn babies with cleft, per region, per year will be known soon. The number of new cases has been estimated by the government by around 5000 new cases each year and only 150 has access to comprehensive care. The cleft epidemiology through the notification report will be performed by pediatricians and social workers at primary care around public and philanthropic maternities around the country contracted by the unified health care system (*Sistema Único de Saúde* [SUS]; Ministry of Health, Brazil). Thus, having a unified cleft classification will be of paramount importance as cleft epidemiology can be known in order to create strategies of care, direct public investments by allocating human resources and building infra-structure, and generating public awareness for this health problem (Raposo-Amaral and Raposo-Amaral 2012).

To date there is no consensus regarding the ideal classification, and several ones have been proposed and adopted around the continent (Table 5.1). The criteria to determine the ideal elements that a classification should present has been described

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Table 5.1 Some classification systems of cleft patients

Classification systems	Description
Davis and Ritchie	
Group 1	Clefts of the lip (without the inclusion of the maxillary alveolus), unilateral, bilateral, or median
Group 2	Clefts inclusive from the maxillary alveolus to the palate, hard and soft
Group 3	Cleft including the alveolus, unilateral, bilateral, or median being complete or incomplete
Veau	
Class I	Cleft of the soft palate
Class II	Clefts of the soft and hard palates, posterior to the incisive foramen
Class III	Complete unilateral cleft lip and cleft palate
Class IV	Complete bilateral cleft lip and cleft palate
Fogh-Andersen	
Group 1	Clefts of the primary palate, including lip, alveolus, and incisive foramen
Group 2	Unilateral and bilateral clefts of the lip (complete or incomplete) that extend into the hard palate
Group 3	Midline clefts of the secondary palate, posterior to the incisive foramen
Group 4	Median cleft lip
Kernahan and Stark	
Group 1	Cleft affecting the primary palate
Group 2	Cleft affecting the secondary palate
Group 3	Cleft affecting primary and secondary palates
ACPA	
Group 1	a. Cleft lip; b. cleft alveolus; c. cleft lip, alveolus, and primary palate
Group 2	a. Cleft of the hard palate; b. cleft of the soft palate; c. cleft of the hard and soft palates
Group 3	Clefts of the prepalate and palate
Group 4	a. Cleft of the mandibular process; b. naso-ocular clefts; c. oro-ocular clefts; d. oroaural clefts

ACPA American Cleft Palate–Craniofacial Association

based on three pillars by the Nomenclature Committee of American Association for Cleft Palate Rehabilitation (Harkins et al. 1962): concise clear definitions of terms, convenience of use, and stimulation of scholarly and clinical research. Although described in 1962, this description is still valid as it guides authors to elaborate new classifications that can persist the span of time and new features, characteristics and findings that may occur in new patients over the years. This aforementioned guide postulated that every new classification should be based on embryology concept as a landmark reference for the division among groups.

In the craniofacial care, one example of a classification that persists the span of time (maintaining updated for almost four decades) as it kept the original characteristic described by the author is the Tessier Rare Facial Cleft Classification (Tessier 1976). Interestingly, even though a cleft lip and palate may show less clinical features and are also less complex compared to the entire scope of rare facial clefts, attempts to describe a cleft lip and palate classification that fill previous weakness, aiming enhanced intelligibility and embracing different anatomic features and severity grades, are still being described.

Looking back to former classifications one can easily understand why the initial classifications did not resist the test of time. In 1922, Davis and Ritchie (1922) described a classification divided on three groups of cleft types morphologically based on the alveolus (Table 5.1). However, patients born either with cleft of the lip and posterior palate with intact cleft alveolus or bilateral with similar characteristics may fail to fit into a single group. Thus, after receiving the criticism of cleft surgeons, this classification was discontinued.

In 1931, Victor Veau (1931) published his book in French named "*Division Palatine*" and described a simple classification anatomically dividing the clefts into four types (Table 5.1). Although widely used and universally accepted at that time, this classification did overlook the cleft patients born with cleft lip alveolus as it also did not embrace in a single classification some rare forms such as cleft of the lip and soft palate. However, it was a redirection and progress of a line of thinking as he used the incisive foramen as an anatomic landmark for division of types II, III, and IV. Poul Fogh-Andersen, plastic surgeon from Copenhagen, went one step further in 1942, by using the incisive foramen as anatomic reference of a cleft type division, showing a more complete comprehensive (or an intuition) toward the marriage between anatomy and embryology, as the concept of primary and secondary palate had been completely overlooked by his predecessors. He additionally included the submucous cleft, a cleft of soft palate, and a cleft of hard palate with intact oral and nasal mucous membrane. Additional modification was done by him (Fogh-Andersen 1971) in 1971 and he added a new group to feature the median clefts (Table 5.1).

Kernahan and Stark (1958) from New York consolidated the concept of embryology and anatomy as they described and defined the primary and secondary palate. They emphasized the embryology knowledge as a requirement for a useful cleft classification. They both were credited for being the first who consolidated the embryological concepts into the description of a cleft classification, by creating the term primary and secondary palate even though it was previously intuitively used by Poul Fogh-Andersen. Cleft of primary palate was defined as a cleft of all anatomic structures anterior to the incisive foramen, whereas cleft of secondary palate was defined as cleft of hard and soft palates posterior to the incisive foramen, occurring at 7–12 weeks of gestation. This classification divided the cleft into three groups (Table 5.1).

In 1962, Vilar-Sancho (1962) classified and coded congenital cleft lip and cleft palate based on Greek nomenclature. Lip was represented by "K" (*keilos*), alveolus by "G" (*gnato*), hard palate by "U" (*urano*), and soft palate by "S" (*stafilos*). Complete cleft was represented in capitals and partial in small letters. "2" was used to represent bilateral, "d" indicated right, "l" indicated left, "I" indicated incomplete, and "o" indicated operated. Being in Greek, it could not be adapted worldwide. It also could not classify many of the cleft subtypes.

In 1962, Harkins et al. (1962) were appointed by American Cleft Palate Association (ACPA) to design a classification of cleft lip and palate. Anatomic segmentation into the prepalate and the palate permitted separation into four major categories of orofacial clefts in the ACPA classification: clefts of the prepalate (cleft of lip and embryologic primary palate); clefts of the palate (cleft of the embryologic secondary palate);

clefts of the prepalate and palate; and facial clefts other than prepalatal and palatal (Table 5.1). Each cleft could be further characterized by laterality (left, right, bilateral, or median) and severity. With regard to severity, the committee chose to use quantitative measurement of the width of the cleft and semiquantitative description of the extent of the cleft. Extent was denoted as 1/3, 2/3, or 3/3 the length or area of the involved structure. Specific criteria were attached to these descriptors for each condition on a case-by-case basis, but they may be thought of as corresponding roughly with minor form, incomplete, and complete, respectively.

In 1969, Santiago (1969) proposed a classification using four digits (0 = no cleft; 1 = midline cleft; 2 = cleft on right side; 3 = cleft on left side; 4 = bilateral cleft) to indicate the presence of cleft and its location. Each digit is followed by a letter to indicate the condition of cleft (complete, incomplete, or submucous). The first digit refers to the lip, the second to the alveolus, the third to the hard palate, and the fourth to the soft palate. The letters indicate more specifically the type of cleft: A = An incomplete midline cleft; B = An incomplete cleft of right side; C = An incomplete cleft of left side; D = Bilateral incomplete cleft; and E = Submucous cleft. When a cleft is not described as being complete or incomplete, it is always assumed as complete cleft. When clefts of lip, hard, and soft palate are described without giving any information about alveolus, it is assumed that it is completely affected by cleft. All cases will be considered midline cleft unless otherwise specified. An example was "4411" which should be interpreted as follows: the first digit indicates bilateral cleft lip, second digit represents bilateral cleft alveolus, third digit shows a midline cleft in hard palate, and last digit shows midline cleft of soft palate. Further example was "001A1" which should be interpreted as follows: The first digit indicates no cleft in lip, second digit indicates no cleft in alveolus, and third digit represents midline cleft of hard palate. The letter A shows that midline cleft is incomplete and last digit indicates a complete midline cleft of soft palate. This classification encompasses a whole range of defects and by the use of machine coding data can be retrieved and used for research purposes.

In 1972, Victor Spina (1973), a Brazilian plastic surgeon, described a terminology modification of a previous classification (namely, International Classification, 1967) by using the Latin term "foraminal" Silva Filho et al. (1992) (Table 5.2). Although it was considered a minor modification of a previous classification that has used the embryologic concept (by using the incisive foramen as an anatomic landmark), it added the rare facial cleft into the cleft lip and palate scheme. It is the most used classification in the Brazilian cleft centers, as it unifies the terms in a simply and clear manner, facilitating verbal communication and referral among centers of SUS. For example, by classifying the cleft patient as post-foraminal, two different pieces of information are communicated; this is a cleft of soft and hard palates extended up to the anterior limit of the incisive foramen and this cleft results from failure of the union of the secondary palate during embryonic period. In addition, although Spina has stated "a partial cleft of lip and of the palate not transversing the incisive foramen would be termed a pre-incisive and pos-incisive foramen cleft," this particular cleft population cannot be included in the numerical order (groups I–IV) established in this particular classification system. Since 2007, we

Table 5.2 Spina and modified Spina's classification systems of cleft patients

Classification systems	Description
Spina	
Group I	Pre-foraminal cleft
a	Unilateral (right or left)
1	Total
2	Partial
b	Bilateral
1	Total
2	Partial
c	Median
1	Total
2	Partial
Group II	Transforaminal cleft
a	Unilateral (right or left)
b	Bilateral
Group III	Post-foraminal cleft
1	Total
2	Partial
Group IV	Rare facial cleft
Modified Spina (SOBRAPAR classification)	
Spina group I	Pre-foraminal cleft[a]
Spina group II	Transforaminal cleft[b]
Spina group III	Post-foraminal cleft[c]
Modified group I/III	Pre-foraminal[a] and post-foraminal[c] cleft without alveolar ridge involvement
Spina group IV	Rare facial cleft

[a]Unilateral (right or left), total or partial; bilateral, total or partial; or median, total, or partial
[b]Unilateral (right or left) or bilateral
[c]Total or partial

have adopted a modified Spina classification with the inclusion of group I/III as it allows the stratification of cleft patients presenting both the pre-foraminal and post-foraminal clefts, but without alveolar ridge involvement. This modified Spina classification has been termed as SOBRAPAR classification (Table). Although this is only a minor modification, we could fit a broad spectrum of cleft patients, therefore facilitating communication between the cleft centers and professionals, only with the description of the group that the patient is included.

In this context, the main criticism related to this system is the absence of assessment of cleft severity (cleft size) and the capacity for prognosis estimation. The Spina classification does not inform if the cleft is 1 mm or 1 cm wide and this specific information might be of major prognostic importance or determine the best approach to be followed. This deficiency is solved by complementing the classification with a parameter of extend, so by listening or receiving the description of a patient, the appearance of the cleft might be visualized as most accurately as possible as well as the best therapeutic options and challenges to be encountered during patient's rehabilitation. The terminology used in this system favors a quick and intuitive interpretation for healthcare professionals less familiarized with the cleft care. We believe that it will be indispensable for creating accurate epidemiology in

Brazil as a reliable tool for compulsory notification done by pediatricians around Brazilian maternities in the future.

A schematic diagram described as Y-shaped diagram was introduced by Kernahan (1971) in 1971 due to the need for optimizing registration and research of cleft types in patient's record. This diagram derived from the perception that most severe, extensive form of cleft lip and palate has the shape resembling this letter, representing the lip, palate, and maxillary alveolus. This Y-shaped system can be divided into nine areas: areas one and four—lip; areas two and five—alveolus; areas three and six—hard palate between the alveolus and the incisive foramen; areas seven and eight—hard palate; and area nine—soft palate. Therefore, this system is merely visual with no applications other than to medical records. In 1998, Smith et al. (1998) proposed a modified classification to compensate the shortcomings of Kernahan striped "Y" classification. It provided more detailed description of the cleft deformities. Cleft lip was divided into additional types denoted "a" to "d" depending on the extent of involved lip. Similarly, cleft of the secondary palate was subdivided into three segments and the submucous cleft of the palate was denoted by the letter "a." In the Smith-modified Kernahan "Y" classification, the submucous cleft palate was denoted by "a" but it did not describe the different varieties of the submucous cleft palate because it can involve the hard palate to different levels. Therefore, in 2013, Khan et al. (2013) proposed a revised Smith-modified Kernahan "Y" classification of the cleft lip and palate, incorporating different varieties of the submucous cleft, which can provide an anatomical basis for the severity of velopharyngeal insufficiency. The submucous cleft palate was denoted by number "7," which was subdivided into four segments: A—submucous cleft palate with involvement of the primary hard palate lying anterior to the incisive foramen and posterior to the alveolus; B—submucous cleft palate with involvement of the palatine process of the maxillary bone of the secondary hard palate; C—submucous cleft palate with involvement of the palatine process of the palatine bone of the secondary hard palate; and D—submucous cleft of the soft palate including occult submucous cleft palate.

Another principle was used by LAHSHAL classification proposed by Kriens in 1985 (Kriens 1989). This term is a palindrome, a projection of the first letters of the names of involved anatomic structures written in English (Lip, Alveolus, Hard palate, Soft palate). The first three letters represent the right side and the last three, the left side. Complete malformations are written in capitals and incomplete in lower case letters. Although it has been suggested that LAHSHAL classification is reliable and reproducible as it has been used by many associations and society of specialties for coding and epidemiology, it eventually became limited because of the ongoing necessity of verbally communicating the classification in different languages. The LAHSN (lip, alveolus, hard and soft palate, and nose) system proposed by Koch et al. (1995) further elaborates on the severity of all single or combined cleft malformations based on the extent of the defect in transverse, vertical, and sagittal directions.

In 1993, Schwartz et al. (1993) introduced an RPL system for numerical coding with 0–3 numbers to simplify the representation of the clefts. In 2001, Ortiz-Posadas et al. (2001) developed a mathematical expression to characterize clefts of the primary palate, including the magnitude of palatal segment separation and the added

complexity of bilateral clefts, yielding a numerical score that reflects overall complexity of the cleft; clefts of the secondary palate were also considered in a separate score. In 2004, Castilla and Orioli (2004) presented ECLAMC (Latin-American Collaborative Study of Congenital Malformations) system for numeral coding. This recording system for oral clefts is based on a simple annotation scheme, or formula, including four fields, representing four clinical topographic areas: lip, alveolar, hard palate, and soft palate; two numbers are to be written into each field, representing the right and left sides; and the numbers express cleft extent in thirds: 0 no cleft, 1 and 2 incomplete cleft, and 3 complete cleft. If only one figure is written within a given field, it means a midline location. Further working definitions for cleft extent are given in a procedure manual. LIP—1: cleft does not go beyond the vermillion; 2: cleft goes beyond the vermillion; and 3: cleft penetrated the nostril. GUM—1: cleft affects less than half of the alveolar height; 2: cleft affects more than half of the alveolar height; and 3: cleft breaks the maxillary arch, which is dislocated. HARD PALATE, as well as SOFT PALATE—1, 2, 3, meaning one, two, or three thirds extension. Numbers other than 0, 1, 2, and 3 are used to specify rare situations such as discontinuous cleft lip and palate, gum notch, submucous cleft palate, healed cleft lip (frustre, or Simonart's band), and other specified anomalies (Castilla and Orioli 2004).

In 2005, Rossell-Perry (2009) from Peru presented a new cleft classification and subsequently published the classification of severity and diagram for cleft description (the clock diagram), which includes the palatal index, a method of evaluation of the cleft palate. This palatal index is adopted to classify cleft palate deformity and select a proper surgical technique based on the severity of the cleft palate and tissue deficiency. This index is the proportion between the width of the cleft (cleft severity) and the sum of the width of the two palatal segments (tissue deficiency) measured at the level of the hard and soft palate junction. The index indicates the amount of soft tissue available for palatal flaps and its relation to the width of the cleft to be repaired. Based on these measurements, the index classifies three degrees of severity for the cleft palate: mild (palatal index of 0–0.2), moderate (0.2–0.4), and severe (>0.4).

In 2007, Liu et al. (2007) from China developed a five-digit numerical recording system for the identification of cleft lip and palate according to the existing classifications, especially the Kernahan "Y" classification, the Smith-modified Kernahan "Y" classification, and the RPL system. The descriptions of the cleft components were anatomically denoted with five Arabic numerals in order of right lip (L), right alveolus and primary palate (A), secondary palate (P), left alveolus and primary palate (A), and left lip (L), otherwise known as the LAPAL system. The extent of cleft deformity is represented by the Arabic numerals 0–4 (i.e., intact through complete cleft). Associated descriptions for cleft lip, cleft alveolus and primary palate, and cleft palate were also provided. In addition, rare atypical craniofacial clefts can also be represented by the LAPAL system by using additional numerals: 5 denotes a median cleft of the upper lip; 6 and 7 denote an oblique facial cleft and transversal facial cleft, respectively; and 8 denotes a median cleft of the lower lip.

Also in 2007, Koul (2007) proposed the expression system that comprises two components, namely anatomical nomenclature (text) and symbols. It is based on the phrase "lip and palate." Uppercase letters signify normal structures and lowercase

letters signify cleft. Laterality of clefts is expressed by + for right side, − for left side, = for median, and ± for bilateral. Absence of an anatomical unit is denoted by #, with the segment denoted by small letters, and submucosal cleft by (), defining the extent of cleft and surface structures represented by uppercase letters. The described examples were "LIP AND PALATE," "liP," "±lip and palate," and "=liP" which should be interpreted as "intact structures without cleft," "incomplete lip cleft," bilateral complete cleft, and median incomplete cleft of upper lip, respectively.

In 2008, Yuzuriha and Mulliken (2008) described lesser form labial clefts (those at the far end of the unilateral incomplete spectrum) as minor form (notched vermillion-cutaneous junction extending 3 mm or more above the normal Cupid's bow peak), microform (notch less than 3 mm above the normal Cupid's bow peak), or mini-microform (disrupted vermilion-cutaneous junction without elevation of Cupid's bow peak). For each, nasal severity reflects that of the lip. Yuzuriha and Mulliken's classification Yuzuriha and Mulliken (2008) is practical because it guides optimal operative technique by cleft severity.

In 2014, Agrawal (2014) proposed a modified Indian classification based on the Indian Classification initially described by Balakrishan (1975). Combinations of clefts were marked with "+" sign, and the abbreviation part of this classification was divided into four parts. Part 1: group ("Gp"). Part 2 (cleft organ): lip ("L"); lip and alveolus ("LA"); cleft lip (1); cleft palate (2); cleft lip, alveolus, and palate (3); and protruding premaxilla ("Pmax"). Part 3 (details): complete (there is no specific notation/abbreviation); partial ("P"); submucosal ("S"); Simonart's band ("sb"); and microform ("m"). Part 4 (side): right ("R"); left ("L"); bilateral ("R + L"); and median ("M"). The described example was "Gp 1R + Gp 3 L" which should be interpreted as "complete cleft lip on right side with cleft lip, alveolus and palate on left side." Further example was "Gp 1R + Gp 3L sb" which should be interpreted as "complete cleft lip on right side with cleft lip, alveolus and palate on left side with Simonart's band on left side."

Luijsterburg et al. (2014) presented, also in 2014, a classification based on patho-embryological events of the primary and secondary palates resulting in various sub-phenotypes of common oral clefts. Patients within the three categories cleft lip/alveolus (CL/A), cleft lip/alveolus and palate (CL/AP), and cleft palate (CP) were divided into three subgroups: fusion defects, differentiation defects, and fusion and differentiation defects. This classification provides new cleft subgroups that may be used for clinical and experimental research.

In 2015, Allori et al. (2015) from the Cleft Kit Collaboration proposed a universal structured form (a longhand structured form and a complementary shorthand notation) for description of cleft lip and/or palate phenotypes. Based on previously described classification systems, this universal structured form included anatomical involvement (pre-foraminal [lip/alveolus] and post-foraminal [palate] descriptions), side (right/left), laterality (unilateral/bilateral/median), severity (complete/incomplete; minor-form/microform/mini-microform; asymmetric), and morphology of the post-foraminal component. It proposed the CLAP notation as acronymic shorthand for the longhand structured form. Uppercase letters summarize the part of the anatomy involved (L, lip; A, alveolus; P, palate).

A lowercase prefix describes the laterality and severity of the pre-foraminal component (lip) (laterality = u, unilateral; b, bilateral; med, median; severity = c, complete; i, incomplete; m, minor-form, microform, or mini-microform; a, asymmetric). A lowercase suffix designates morphology of the post-foraminal component (secondary palate; bu, bifid uvula; sm, submucous; v1, v2, v3, and v4, Veau I–IV, respectively). CLAP notation should be read from left to right and translates directly to the structured form. The described example was "right ucCLAPv3" which should be interpreted as "right unilateral complete cleft of the lip and alveolus with a palate that is Veau III."

5.2   Summary

Cleft lip and palate are marked by a wide diversity in terms of clinical types, making classification difficult. In this chapter we included an overview of the classification of cleft phenotypes to facilitate diagnosis, management, surgical treatment, and research.

Classifications are very important not only for clinical diagnostic of syndromic and nonsyndromic cleft patients but also to define the long-term prognostic of these patients. The size and localization of the cleft would preview the facial growth and also the final result for speech. The new classification with the localization in the primary palate or only in the secondary palate with the severity could predict the final rehabilitation of these patients with or without final good speech.

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