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Nasoendoscopic findings after primary palatal surgery: can the Furlow technique result in a smaller velopharyngeal gap?

Achados nasoendoscópicos após a cirurgia primária de palato: a técnica de Furlow pode resultar em menor gap velofaríngeo?

ABSTRACT

Purpose: To compare the nasoendoscopic findings related to the velopharyngeal gap among patients with cleft palate who underwent the Furlow (F) technique and those who underwent the von Langenbeck (vL) technique for primary palatal surgery, who remained with velopharyngeal insufficiency (VPI). **Methods:** The analyzed data were retrieved from the institution's data of recordings of nasoendoscopic exams. The sample comprised 70 recorded nasoendoscopic exams obtained from 22 patients who underwent the F technique and from 48 who underwent the vL technique during primary palatoplasty, who remained with VPI after surgery and were submitted to nasoendoscopy, between the ages of 5 and 15 years (mean age: 8 years), for definition of the best treatment for VPI. The images were edited into a DVD in a randomized sequence to be assessed by three experienced speech language pathologists regarding displacement and excursion of the soft palate; displacement and excursion of lateral pharyngeal's walls; displacement and excursion of the posterior pharyngeal's wall; and presence of the Passavant ridge and size and type of velopharyngeal gap. **Results:** The results of the comparison of measurements between F and vL groups were not statistically significant. **Conclusion:** The surgical technique used in primary palatoplasty was not relevant to determine the difference in the size of the velopharyngeal gap for patients who maintained VPI.

RESUMO

Objetivo: Comparar os achados nasoendoscópicos relacionados ao *gap* velofaríngeo entre pacientes com fissura labiopalatina operados do palato pela técnica de Furlow (F) e aqueles operados pela de Von Langenbeck (vL) que permaneceram com insuficiência velofaríngea (IVF). **Métodos:** Os dados analisados foram coletados do banco de gravações de exames de nasoendoscopia da instituição. A amostra foi constituída por 70 gravações de nasoendoscopia obtidas de 22 pacientes operados do palato pela técnica de F e de 48 pela de vL, que permaneceram com IVF e que foram submetidos à nasoendoscopia para definição de conduta para correção da IVF, entre as idades de 5e 15 anos (média: 8 anos). As imagens foram editadas em sequência aleatória em um DVD e julgadas por três fonoaudiólogas experientes quanto ao movimento e deslocamento do véu palatino; ao movimento e descolamento das paredes laterais da faringe; ao movimento e deslocamento da parede posterior da faringe; à ocorrência da prega de Passavant e ao tamanho e tipo do *gap* velofaríngeo. **Resultados:** Os resultados quanto à comparação das medidas entre as técnicas cirúrgicas (F *versus* vL) não foram estatisticamente significantes. **Conclusão:** A técnica cirúrgica utilizada na palatoplastia primária não foi relevante para determinar diferença no tamanho do *gap* velofaríngeo para os pacientes que permaneceram com IVF.

Study carried out at the Hospital for Rehabilitation of Craniofacial Anomalies, Universidade de São Paulo – USP – Bauru (SP), Brazil.

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INTRODUCTION

Surgical corrections of cleft lip and palate, comprising the primary lip repair (surgery for lip correction) and primary palatoplasty (reconstruction of hard and/or soft palate), are recommended in the first year of life.

Primary palate surgery can be performed through various surgical techniques, of which the best for the type and the extent of the cleft is chosen, always seeking correction from the anatomic and functional point of view. Surgical failure may occur due to the surgical technique, the surgeon's skill, and/or the extent of the cleft palate^(1,2). A secondary physical intervention is usually needed to correct palatal fistula or dysfunction of the velopharyngeal mechanism (VPM). Failure of the VPM is called velopharyngeal dysfunction (VPD), which occurs due to lack of tissue (velopharyngeal insufficiency – VPI) or lack of functionality (velopharyngeal incompetence)^(3,4).

The ideal age for surgical correction of cleft palate remains controversial. Most recent studies argue in favor of early age, between 6 and 18 months, to promote normal speech acquisition and to prevent hearing loss^(5,6). Other surgeons have advocated two surgeries for complete cleft, in which the closure of the soft palate is performed between 3 and 8 months, whereas the hard palate is postponed until 15 months to 15 years of age^(7,8).

It is through primary palatoplasty that VPD is prevented in children with cleft palate. In addition to age and the surgeon's skill, the choice of surgical technique is one of the most important factors. It should provide not only the closing of the anatomical part of the cleft but also allow sufficient stretching and mobility of the soft palate so that it interacts with the pharyngeal walls when the velopharyngeal closure (VC) is required for speech^(1,2).

Some studies have indicated that, even after the palate correction, an incidence of VPD, which can range from 5 to 36%, may occur, even when the individual undergoes surgery under conditions considered ideal. However, this proportion may increase considerably when the patients undergo surgery late in their lives, or when the choice of surgical technique did not consider circumstances relevant to speech^(3,9,10).

The repair of cleft palate was first described by von Langenbeck (vL) in 1861, whose technique, which is named after him, highlights the importance of the separation of the oral and nasal cavities, principle used in most of the techniques to date^(6,11,12). Many authors pointed out that the disadvantage of this technique is that it does not lengthen the palate sufficiently for the reconstruction of the VPM^(6,13).

The Furlow (F) technique is a palatoplasty that uses a mirrored Z-plasty of the oral and nasal mucosa, providing greater palate elongation and restoring muscle strength^(6,14). A prospective clinical trial study compared the results of speech and of velopharyngeal function in patients with cleft lip and palate who underwent surgery through the F and vL techniques and found better outcomes for patients operated through the F technique⁽⁶⁾. Other studies reported superior results on speech for patients operated through the F technique when compared with other surgical techniques⁽¹⁵⁻¹⁷⁾.

The VPM is evaluated through a perceptual evaluation of speech⁽¹⁾. However, it is very common that this assessment be complemented with instrumental techniques, especially nasoendoscopy and videofluoroscopy^(4,18). Nasoendoscopy, specifically, is a technique that allows direct visualization of velopharyngeal structures and their movements during speech^(4,9). It complements the clinical evaluation and allows the team to define the best approach to be used. It also allows the realization of displacement measurements of each velopharyngeal structure and to estimate, although subjectively, the size and type of velopharyngeal gap⁽¹⁹⁻²¹⁾.

Because the F technique calls for greater extension of the soft palate through the repositioning of the fibers of the soft palate muscles, this study raises the following hypothesis: do patients in the study by Williams et al.⁽⁶⁾, operated through the F technique and who remained with velopharyngeal insufficiency after surgery, present a smaller VP gap than those operated through the vL technique, which also remained with VPI?

This study aimed to compare the nasoendoscopic findings related to the VP gap between patients who underwent cleft palate surgery through the F technique and those operated through the vL technique.

METHODS

This project was approved by the Research Ethics Committee of the Hospital for Rehabilitation of Craniofacial Anomalies of Universidade de São Paulo, under protocol No. 571.365 – 25/03/2014.

The data were obtained from an analysis of the nasoendoscopy recordings databank of patients participating in the Florida Project who had suspected VPD. This project, conducted in partnership between the Hospital for Rehabilitation of Craniofacial Anomalies of Universidade de São Paulo and the Craniofacial Center at the University of Florida (USA), between 1995 and 2006, was a prospective, randomized study financed by the National Institute of Health - NIH/NIDCR (R01-DE10437), which aimed at comparing the speech and velopharyngeal function results in patients with unilateral cleft palate, who underwent surgery through the F and the vL techniques. The speech and velopharyngeal function results generated a huge database of clinical and instrumental protocols, including nasoendoscopy. Patients in the Florida Project who were referred to nasoendoscopy were those who had suspected VPD, who presented scores above 2/10 in the Nasal Air Emission Test and/or 2/10 in the Hypernasality Test⁽⁶⁾.

The 187 recordings of nasoendoscopy exams in the Florida Project databank were viewed one by one and tabulated in a Microsoft® Excel table. To select which exams would comprise the sample for this study, the exams selected were those from patients who

- presented VPI after primary palatoplasty;
- did not present palatal fistula; and
- presented the nasoendoscopy recording for evaluation of VPD during the emission of the syllable sequence “papapa,” with good technical quality of image and sound, carried

out between the ages of 5 and 15 years (mean age 8 years) before any secondary surgical interventions to correct VPI.

After the inclusion criteria were applied, the study sample was then composed of 70 nasoendoscopy recordings made between 2002 and 2011, of 70 patients (one per patient), 22 of whom underwent surgery through the F technique (13 boys and 9 girls) and 48 through the vL technique with intravelar veloplasty (30 boys and 18 girls), who had palate surgery between 9 and 18 months of age.

The nasoendoscopy exams were performed by experienced professionals in the medical and speech language areas of the Florida Project, using a flexible nasoendoscope (model ENF type P4; Olympus). Samples for analysis were edited from the recordings of the selected exams. The images were edited at rest and during the emission of the syllable sequence “papapa”, replicated four times to facilitate analysis.

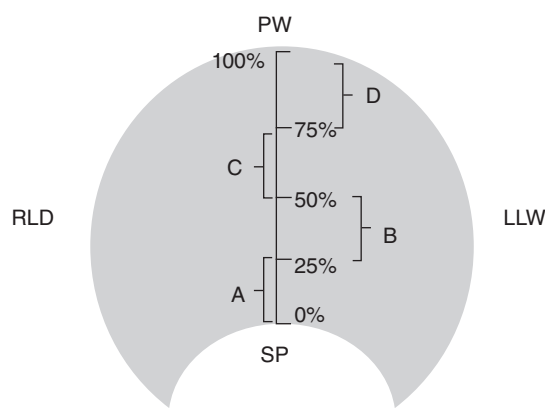
The nasoendoscopic findings were analyzed using an adaptation of the protocols proposed in the literature^(20,21). These protocols are models of semiquantitative measures that were developed to standardize the collection of information on the functioning of the VPM through nasoendoscopy. They are based on relative measures, with the classification of the contrast between the resting position and the amount of displacement of the pharyngeal structures.

The measures of interest were collected by three experienced speech language pathologists, hereinafter referred to as judges. So that the judges could have a reference to analyze the aspects of the protocol, a manual was developed (in Microsoft® PowerPoint) illustrated with guidance on every aspect analyzed, with recordings and/or images of exams that could be found in the samples. The judges could see the manual as many times as deemed necessary, until they feel secure to respond the analyzed aspect in time through a consensus, and the judgment was conducted from the speech segment that represent the largest displacement of the structures under analysis. The following is a description of each of these aspects:

- soft palate movement: the judges should observe the presence or absence of movement of the soft palate;
- maximum displacement of the soft palate: the judges should estimate the extent, in percentage, of the maximum displacement of the soft palate, considering that the latter, at rest, has its value set at 0%; the posterior pharyngeal wall, at rest, has its value set at 100%; and the center of the VPM, at rest, has its value set at 50%. According to the protocol, the maximum displacement of the soft palate could fall into four measures: 0-25%, 26-50%, 51-75%, and 76-100% (Figure 1);
- movement of the posterior pharyngeal wall: the judges were asked to identify the presence or absence of movement of the posterior pharyngeal wall;
- maximum displacement of the posterior pharyngeal wall: the judges should estimate the extent, in percentage, of the maximum displacement of the posterior wall in relation to the soft palate, considering that the wall at rest has reference value set at 0% and the soft palate at rest has reference value set at 100%. Thus, according to

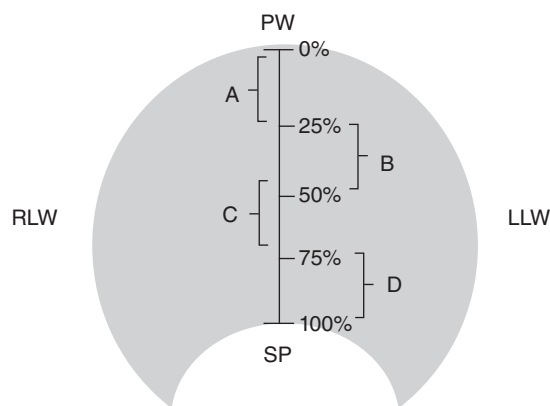
the protocol, the maximum displacement of the posterior wall could fall into four measurements: 0–25%, 26–50%, 51–75%, and 76–100% (Figure 2);

- movement of the lateral pharyngeal walls: the judges should identify the presence and absence of movement of the right and left lateral walls;
- maximum displacement of the lateral pharyngeal walls: the judges should estimate the measurement, in percentage,



Caption: PW = posterior pharyngeal wall; PLD = right lateral wall; PLE = left lateral wall; SP = soft palate

Figure 1. Reference scheme of displacement of the soft palate in four quadrants. A: 0–25%; B: 26–50%; C: 51–75%; D: 76–100%

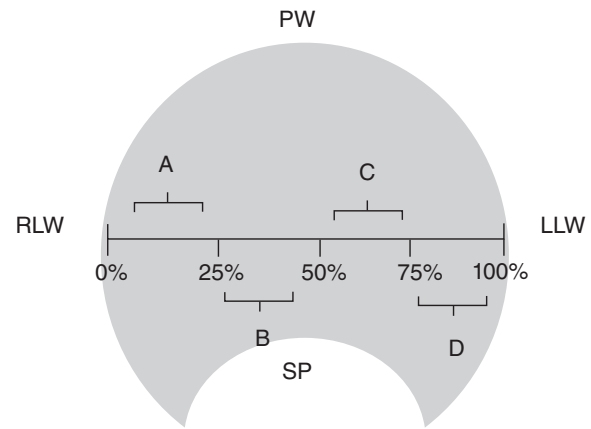


Caption: PW = posterior pharyngeal wall; PLD = right lateral wall; PLE = left lateral wall; SP = soft palate

Figure 2. Reference scheme of the displacement of the posterior pharyngeal wall in four quadrants. A: 0–25%; B: 26–50%; C: 51–75%; D: 76–100%

of the maximum displacement of the right and left lateral walls, relative to one another, considering that the wall at rest has a reference value set at 0%, and the other has a reference value set at 100%. Thus, according to the protocol, the maximum displacement of right and left walls could fall into four measurements: 0–25%, 26–50%, 51–75%, and 76–100% (Figure 3);

- Passavant’s pad: the judges should judge whether there was the presence of the Passavant’s pad;
- VP gap size: the judges should quantify the VP gap size according to the reference measurements, that is, quantify the space that was left of the maximum movement of velopharyngeal structures and not how much the structures per chance had moved. For this reason, they should compare the image at rest with the image of the structures at maximum displacement. When there was no movement of velopharyngeal structures (where the image at rest is equal to the image of the maximum displacement), they should measure the gap size at 100%. The reference measures adopted for this item were subdivided on a six-point adapted scale^(20,21): 0%, VP closure; 10%, VP gap with air bubble; 25%, small



Caption: PW = posterior pharyngeal wall; PLD = right lateral wall; PLE = left lateral wall; SP = soft palate

Figure 3. Reference scheme of the displacement of the lateral pharyngeal wall in four quadrants. A: 0–25%; B: 26–50%; C: 51–75%; D: 76–100%. On the left wall, the measurements are reversed

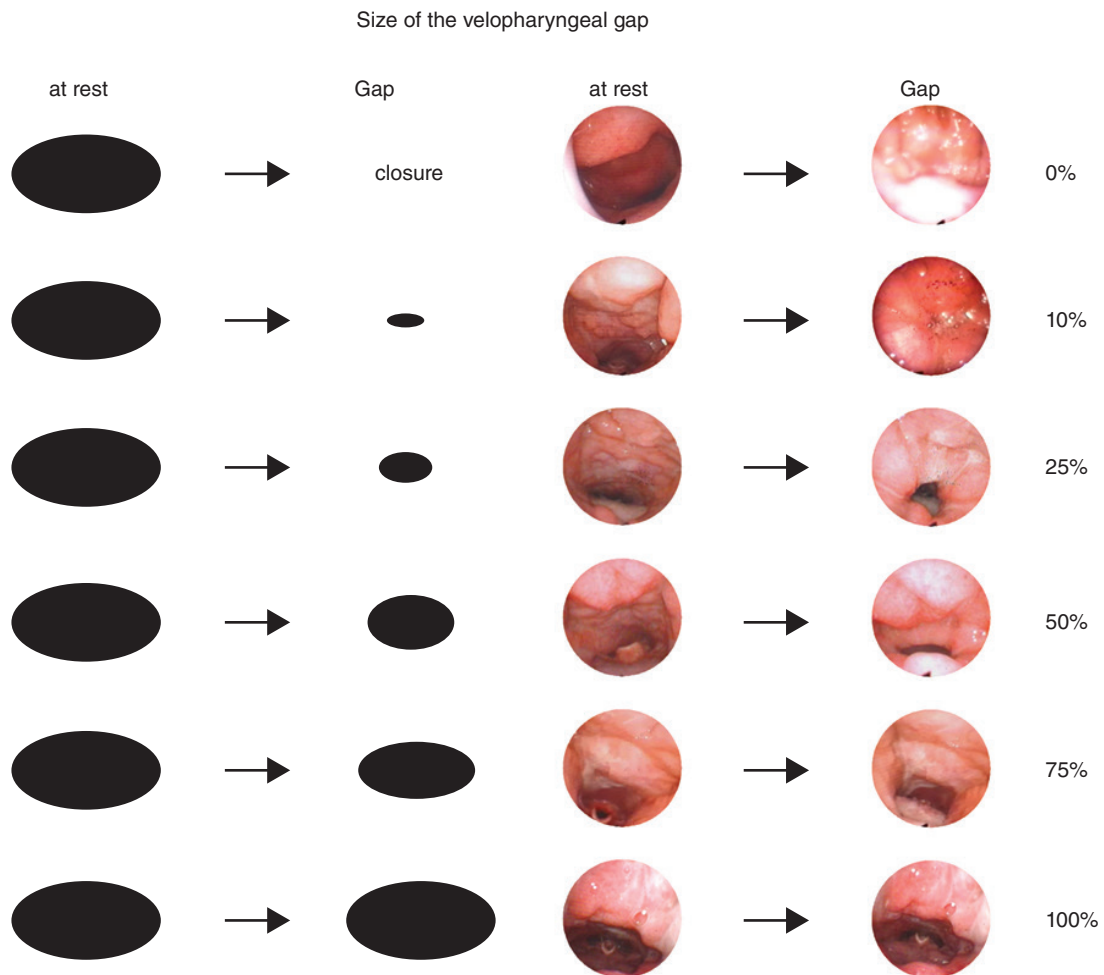


Figure 4. Reference scheme of the measurement of the velopharyngeal gap, where 0% = velopharyngeal closure; 10% = velopharyngeal gap with air bubble; 25% = small velopharyngeal gap; 50% = medium velopharyngeal gap; 75% = large velopharyngeal gap; and 100% = very large velopharyngeal gap

- VP gap; 50%, medium VP gap; 75%, large VP gap; 100%, very large VP gap (Figure 4); and
- type of VP gap: the judges should classify the type of VP gap, observing the behavior of all structures, according to the following classification⁽¹⁹⁾:
 - Sagittal: there is a predominance of movement of the lateral pharyngeal walls as compared to other velopharyngeal structures;
 - Coronal or transverse: there is a predominance of movement of the soft palate (upward and backward) when compared to the other structures;
 - Circular: there is a “homogeneous” participation of the soft palate and lateral pharyngeal walls; and
 - Circular with Passavant’s pad: the circular type occurs with the formation of a Passavant’s pad in the posterior pharyngeal wall.

For statistical analysis, the results for each aspect evaluated among patients who underwent surgery through the F technique and those who underwent surgery through the vL technique were compared using Fisher’s statistical test for movement of the soft palate and of the lateral walls, maximum displacement of the soft palate and posterior wall, and type of VP gap. The χ^2 -test was applied to the movement of the posterior pharyngeal wall, maximum displacement of the lateral pharyngeal wall, and Passavant’s pad. As for the size of the VP gap, the Mann–Whitney’s test was used. Results with $p < 0.05$ were considered statistically significant for these tests.

RESULTS

The presence of soft palate movement was observed for all (100%) patients who had surgery through the F technique and for 46 (96%) patients who had surgery through the vL technique. The difference between these results was not significant (Fisher’s exact test, $p = 1.000$). The maximum displacement of the soft palate between 0 and 25% occurred for 7 (32%) patients who had surgery using the F technique and 11 (23%) who underwent surgery using the vL technique; between 26 and 50% for 4 (18%) of F and 3 (6%) of vL; between 51 and 75% for 3 (14%) of F and 7 (15%) of vL; and between 76 and 100% for 8 (36%) of F and 27 (56%) of vL. The comparison of the results was not statistically significant (Fisher’s exact test, $p = 0.282$).

The movement of the posterior pharyngeal wall was observed for 10 (45%) patients of the F technique and 19 (39%) of the vL technique. The difference between the results was not significant (χ^2 -test, $p = 0.840$). The maximum displacement of the posterior pharyngeal wall between 0 and 25% occurred for 19 (86%) patients of the F technique and 42 (87%) of the vL technique; between 26 and 50% occurred for 3 (14%) of F and 6 (13%) of vL. There was no displacement over 50% in both primary palatoplasty techniques for any patient. The results between the comparisons were not statistically significant (Fisher’s exact test, $p = 1.000$).

The movement of the right and left pharyngeal walls occurred for all patients of the F technique. However, in the vL

technique, the movement of the right pharyngeal wall occurred for 45 (94%) and the movement of the left pharyngeal wall occurred for 43 (93%) patients. The results of the comparisons were not statistically significant (Fisher’s exact test, right wall, $p = 0.547$; left wall, $p = 0.546$). The maximum displacement of the right and left pharyngeal wall was not statistically significant (χ^2 -test, $p = 0.925$; $p = 0.468$ – Table 1).

The presence of the Passavant’s pad was observed in 7 (32%) patients of the F technique and in 14 (30%) of the vL technique. The comparison between the results was not statistically significant (χ^2 -test, $p = 0.955$).

The size of the VP gap at 0% did not occur to any of the patients who underwent surgery through the F technique and occurred only in 2 (4%) who underwent the vL technique; at 10% for 5 (23%) patients of F and 16 (33%) of vL; at 25% for 7 (32%) of F and 7 (15%) of vL; at 50% for 4 (18%) of F and 12 (25%) of vL; at 75% for 6 (27%) of F and 10 (21%) of vL; and at 100% for none (0%) of F and 1 (2%) of vL. Differences between the comparisons of results were not statistically significant (Mann–Whitney’s test, $p = 0.531$ – Table 2).

The coronal VP gap occurred for 8 (36%) patients of F and 20 (42%) of vL; sagittal occurred for 2 (9%) of F and (2%) with vL; circular occurred for 7 (32%) of F and 18 (37%) of vL; and circulate of Passavant’s pad occurred for 5 (23%) of F and 9 (19%) of vL. A comparison of the results was not statistically significant (Fisher’s exact test, $p = 0.557$ – Table 3).

Table 1. Distribution of numbers and percentages of patients who underwent surgery through the Furlow and von Langenbeck techniques, according to the values of the maximum displacement of the lateral pharyngeal walls

| Maximum displacement of the lateral pharyngeal walls | Furlow n (%) | | von Langenbeck n (%) | |
|--|-----------------|----------|-------------------------|----------|
| | RS | LS | RS | LS |
| 0–25% | 16 (73) | 17 (77) | 37 (77) | 30 (65) |
| 26–50% | 6 (27) | 5 (23) | 11 (23) | 16 (35) |
| 51–75% | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 76–100% | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Total | 22 (100) | 22 (100) | 48 (100) | 46 (100) |
| p-value | 0.925* | | 0.468* | |

Caption: RS = right side; LS = left side

*Significant values ($p < 0.05$) – χ^2 test

Table 2. Distribution of the number of patients who underwent surgery through the Furlow and von Langenbeck techniques, according to the values obtained regarding the size of the velopharyngeal gap

| Size of the velopharyngeal gap | Furlow n (%) | von Langenbeck n (%) |
|--------------------------------|-----------------|-------------------------|
| 0% | 0 (0) | 2 (4) |
| 10% | 5 (23) | 16 (33) |
| 25% | 7 (32) | 7 (15) |
| 50% | 4 (18) | 12 (25) |
| 75% | 6(27) | 10 (21) |
| 100% | 0 (0) | 1 (2) |
| Total | 22 (100) | 48 (100) |
| p-value | 0.531* | |

*Significant values ($p < 0.05$) – Mann–Whitney’s test

Table 3. Distribution of the number of patients who underwent surgery through the Furlow and von Langenbeck techniques, according to the type of velopharyngeal gap

| Type of velopharyngeal gap | Furlow n (%) | von Langenbeck n (%) |
|----------------------------|-----------------|-------------------------|
| Coronal | 8 (36) | 20 (42) |
| Circular | 7 (32) | 18 (37) |
| Circular with Passavant | 5 (23) | 9 (19) |
| Sagittal | 2 (9) | 1 (2) |
| Total | 22 (100) | 48 (100) |
| p-value | 0.557* | |

*Significant values ($p < 0.05$) – Mann-Whitney's test

DISCUSSION

The results of this study did not confirm the hypothesis that patients who presented VPI after the F technique and primary palatoplasty presented with a smaller VP gap than those who underwent surgery with the vL technique. All comparisons of velopharyngeal structures observed no significant difference.

When interpreting these findings, it is important to consider that the surgical reorganization of the palatal muscles, as conducted in both techniques, may have had a similar impact on the gap size. The F technique, for example, stretches the soft palate through two mirrored zetaplasties involving oral and nasal flaps (mirrored between planes) with transposition of the flaps, which involves muscular retroposing^(2,6,12). However, the vL technique with intravelar veloplasty requires the release and thorough dissection of the muscles, also allowing posteriorization of the muscle fibers^(6,11,22). That is, both techniques involve release and posteriorization of muscle fibers and, although the procedures for manipulation of the muscle fibers are different between the techniques, the results in terms of VP gap are similar, as observed in this study.

The palatopharyngeal fibers in patients with cleft palate run along the levator muscle of the soft palate⁽²³⁾. The horizontal fibers of this muscle can produce a sphincteric action, medializing the lateral pharyngeal walls narrowing the nasopharynx and help with VP closure⁽²⁴⁾. Some authors suggested that the palatopharyngeal muscle works as a “hydrostatic” muscle, which helps contract the posterior portion of the soft palate, molding the shape of the posterior pharyngeal wall and resulting in a better VP sealing^(25,26). Therefore, the techniques used in this study can influence the movement of the pharyngeal walls, as both involve repositions the palatopharyngeal muscle leading to functional and anatomical competence.

The ability of the surgeon to conduct the surgical technique has been cited as an important factor in the outcome of the treatment of cleft lip and palate⁽⁶⁻¹¹⁾. The surgeons involved in this study were using the vL procedure as the routine surgical technique for primary repair of cleft lip and palate while they were trained to perform the F technique for the study. Despite the greater skill with the routine technique (vL) when compared with the innovative procedure (F), the expected longer soft palate and, therefore, smaller gap with the F procedure, was not observed.

The presence of the expected pharyngeal tonsil in speakers aged between 9 and 13 years⁽²⁷⁾ may have been a variable that affected the findings, since nasoendoscopic examinations were conducted in patients between 5 and 15 years (mean age 8 years). The literature refers to veloadenoidal closure, at this age^(28,29). It is assumed, however, that the presence of the tonsil at different stages of involution was distributed equally between the two populations. That is, if there was participation of the tonsil in VC, it occurred equally for the F and vL procedures.

The velopharyngeal function can be affected by vocal intensity and by the different levels of intraoral and subglottic pressure used by speakers during speech production^(1,4,12). This study did not involve the conduction of perceptual evaluation of speech samples obtained during the nasoendoscopic exam. It is suggested that this limitation should be better controlled in future studies because the use of compensatory articulation and the presence of hypernasality and nasal air escape may interfere with the movement of velopharyngeal structures^(1,12).

For this study, the selected stimulus for speech sampling production was the sequence “papapa”, since it was the most frequent speech stimulus in the database, providing a larger number of recordings for the study. Although the phonetic content of the speech sample was controlled, the ideal would be to include more representative samples of connected speech (phonetically balanced)^(20,30).

Although the group studied had more nasoendoscopy tests with VPI in patients who underwent surgery with the vL technique than those who underwent surgery with the F technique, the characteristics of the gaps between the groups were similar. The sample size was not controlled since the purpose of this study was to evaluate all the nasoendoscopic exams in the databank.

CONCLUSION

The surgical technique used in primary palatoplasty was not relevant to determine difference in velopharyngeal gap size for patients who maintained VPI.

**GZF participated in the development and design of the study, data collection, analysis and interpretation of data, and drafting and revision of the article; JCRD carried out the study design, analysis, and interpretation of data, as well as the drafting and revision of the article; MEW, OMVS, and VCCM carried out the analysis and interpretation of data; MIPK conducted the study design, data collection, analysis, and interpretation of data and also the drafting and revision of this article.*

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