

Characterization of the pattern of velopharyngeal closure in cleft palate patients

Caracterização do padrão de fechamento velofaríngeo em pacientes com fissura palatina

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ABSTRACT

Purpose: To characterize the velopharyngeal closure pattern in patients submitted to cleft palate surgery and its relation with gender, age, cleft type, and diagnosis of velopharyngeal function. **Methods:** Retrospective study based on 89 nasopharyngoscopy studies of operated cleft palate patients with ages between 4 and 47 years (mean=17.32±10.50). Data were analyzed regarding gender, age range (4 to 8, 9 to 12, 13 to 18 and >18 years), cleft type (postforamen or transforamen), diagnosis of velopharyngeal function (adequate, borderline, and inadequate), and velopharyngeal closure patterns (coronal, circular, circular with Passavant's ridge, and sagittal). Results were statistically analyzed. **Results:** In the study sample, 59.55% of the patients were women; 39.33% were above 18 years of age; 44.94% had post-foramen cleft and 55.06%, transforamen cleft; 14.61% showed adequate, 53.93% borderline, and 31.46% inadequate velopharyngeal closure. With regards to the velopharyngeal closure pattern, 37.08% of the subjects presented coronal closure; 33.71%, circular closure, 15.73% circular with Passavant's ridge; and 13.48%, sagittal closure pattern. There was a relation between pattern of closure and diagnosis of velopharyngeal function (p=0.05). **Conclusion:** Most of the sample presented coronal pattern of velopharyngeal closure, followed by circular, circular with Passavant's ridge and sagittal patterns. There was no relationship between closure pattern and the variables gender, age, and cleft type, but there was a related influence to the diagnosis of velopharyngeal function.

Keywords: Cleft palate; Nasopharynx; Soft palate; Velopharyngeal insufficiency; Endoscopy

INTRODUCTION

The velopharyngeal mechanism is constituted by the muscles of the soft palate, posterior and lateral pharyngeal walls⁽¹⁾, separating the oropharynx from the nasopharynx. Such structures, particularly the soft palate, play a key role in the velopharyngeal closure physiology⁽²⁾.

Velopharyngeal closure patterns may be classified as follows: coronal, where there is predominant soft palate movement toward the posterior pharyngeal wall; sagittal, where there is predominant movement of the lateral pharyngeal walls toward the pharynx midline; circular, where balanced movements of lateral pharyngeal walls and soft palate are observed; circular with Passavant's ridge, where the circular closure is associated

with the development of a mucosal fold named Passavant's ridge on the posterior pharyngeal wall⁽³⁾.

The velopharyngeal closure allows the separation between the nasal and oral cavities during activities such as oral sounds emission, blowing, whistling, swallowing, sucking and vomiting reflex, respecting the level of closure demanded by each activity^(4,5).

Particularly in speech, the velopharyngeal mechanism allows the expiratory airflow coming from the lungs and the sound produced by the vocal folds to be directed toward the oral cavity in the generation of oral sounds, and toward the nasal cavity in the generation of nasal sounds. Also, it has the function of aiding in the oronasal resonance balance besides providing appropriate intraoral pressure.

In cases where the structures of the velopharyngeal mechanism do not work properly, the presence of a space called velopharyngeal aperture is observed between them, characterizing a velopharyngeal dysfunction. One of the reasons for the occurrence of such an aperture is the absence of soft palate tissue, i.e., the presence of a short soft palate. This dysfunction is called velopharyngeal insufficiency and may be corrected either surgically or by prosthetic management followed by speech therapy. In cases where such dysfunction

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occurs because of a failure in the velopharyngeal structures movement, physiological or neuromotor deficiency, it is called velopharyngeal incompetence that may be eliminated by means of speech therapy^(2,6). On the other hand, if such condition is a result from the presence of compensatory articulations or other speech learning errors, it does not reflect physical or neuromuscular alterations, constituting indication for speech therapy⁽⁷⁾.

Individuals with velopharyngeal dysfunction present hypernasality, nasal air emission, poor intraoral pressure, and may present associated nasal/ facial movements and compensatory articulations during the emission of oral consonants^(8,9).

Cleft lip and palate is a congenital deformity that may be classified into three major groups: preforamen incisor cleft, corresponding to either a (left/right) unilateral medial or bilateral split of the upper lip that may be complete (affecting the lip/alveolar ridge) or incomplete (affecting only the lip); post-foramen incisor cleft, presence of a palate fissure that may be complete (affecting both the soft and hard palate) or incomplete (partially affecting the palate); transformen incisor cleft, involving the upper lip and palate, that may be classified into unilateral (affecting only one side) and bilateral (affecting both sides)⁽¹⁰⁾. Submucous cleft, a post-foramen incisor cleft subtype, is characterized by a fissure on the bony and muscular portions of the palate in association with integrity of the oral mucosa involving such region⁽¹⁰⁻¹²⁾. Only clefts affecting the palate will be approached in the present study, since only such a condition can cause velopharyngeal dysfunction.

Palatoplasty is indicated in cases where the cleft affects the palate. This surgery consists of anatomical and functional reconstruction of the palate, allowing the separation of the oral and nasal cavities⁽¹³⁾. Such surgery should preferentially be performed around the twelfth month of life, since better functional outcomes are observed in cases where it is precociously performed^(14,15). However, such surgery not always offers satisfactory results in terms of signs and symptoms caused by the velopharyngeal dysfunction; and a further surgery is required in cases of velopharyngeal insufficiency.

Velopharyngeal rehabilitation is the target of the surgical techniques for management of velopharyngeal insufficiency, according to the individual patient's requirements, with the objective of correcting the hypernasality and nasal air escape, and improving the conditions of intraoral pressure and oral airflow^(16,17). But the surgical intervention does not necessarily imply speech improvement, and many times postoperative speech therapy is required. Palatal prosthesis is another treatment option that may be either temporary or permanent, being utilized in cases where surgery is unsuccessful or not feasible, with the same above mentioned objectives^(18,19).

Perceptual and instrumental evaluations may be utilized to assess the velopharyngeal function and to establish the differential diagnosis of velopharyngeal dysfunction as well as to define the approach to be adopted.

Videofluoroscopy and nasopharyngoscopy represent the main imaging tools for evaluating the pattern of velopharyngeal closure^(4,20,21), the latter being the method of choice in the development of the present study.

Nasopharyngoscopy constitutes a direct method for evaluating the velopharyngeal function, allowing the visualization of velopharyngeal structures, even during speech. This method is considered as a key tool in the evaluation of anatomical features of the velopharyngeal closure and, together with the clinical perceptual evaluation, plays a significant role in the diagnosis of velopharyngeal dysfunction, contributing to the definition of the approach and treatment to be adopted⁽²⁰⁾.

In Brazilian literature, some studies describe the pattern of velopharyngeal closure in healthy speakers^(1,22), but there are scarce studies aimed at describing such a pattern in patients submitted to surgery for cleft palate, which might be used as a reference for further studies.

Thus the present study was aimed at characterizing the velopharyngeal closure pattern in patients submitted to surgery for cleft palate and evaluating its relation with gender, age, cleft type, and diagnosis of velopharyngeal function.

METHODS

The present study was approved by the Research Ethics Committee of Pontifícia Universidade Católica de Minas Gerais (PUC Minas) under number CAAE - 0086.0.213.000-09.

The present study was based on the analysis of nasopharyngoscopy studies of operated cleft palate patients of the Clinical Center for Speech-Language Pathology and Audiology of PUC Minas, with the objective of evaluating velopharyngeal closure. All the studies were performed by a single experienced otolaryngologist, with the collaboration of a single, also experienced, speechlanguage therapist. All the procedures were video-recorded. Both the velopharyngeal function diagnosis and the characterization of the closure pattern were consensually determined by the observers at the moment of the study. In case of doubt, immediately after the procedure, the video was reviewed by both observers until a consensus was achieved.

The study sample included all the nasopharyngoscopy results obtained in both male and female operated cleft palate patients aged above four years, in the period from 2004 to 2009. The data were analyzed in relation to patients' gender, age range (4-8 years, 9-12 years, 13-18 years and >18 years), cleft palate type (postforamen incisor cleft and transformen incisor cleft), prevalent velopharyngeal closure pattern (coronal, circular, circular with Passavant's ridge and sagittal), and velopharyngeal function diagnosis (adequate, borderline and inadequate).

During the procedure, care was taken not to evaluate the velopharyngeal function in the presence of compensatory articulations during phonation, since they could directly affect the velopharyngeal function⁽²³⁾.

Results of studies where the patient failed to cooperate or whose images did not allow the categorization of the velopharyngeal closure pattern constituted exclusion criteria. Additionally, cases of patients with velopharyngeal dysfunction from unknown causes or those previously submitted to pharyngoplasty were also excluded.

Statistical analysis was performed with the Minitab 15

software, by means of hypothesis testing to establish possible statistical significance for the frequency of each of the analyzed aspects. Additionally to the hypothesis testing, the Fisher's exact test was performed with the Epi Info 6 software to analyze the association between velopharyngeal closure pattern and the gender, age range, cleft palate type, and velopharyngeal function diagnosis variables. Statistical significance was set at 5% for all the tests.

RESULTS

The sample included nasopharyngoscopy studies of 89 patients (59.55% women, and 40.45% men) in the age range from four to 47 years (mean=17.32 years, SD=10.50 years). Among such patients, 44.94% presented post-foramen incisor cleft and 55.06%, transforamen incisor cleft. The statistical analysis demonstrated a significant difference ($p=0.045$) between frequencies for female and male patients in the study sample.

Table 1 presents the frequency of responses for each aspect evaluated, demonstrating the number of patients (n) and respective percentages, besides the p-value corresponding to the statistical significance of determined characteristic incidence in the studied population. It may be observed that most of the patients who had their studies analyzed were aged above 18 years; transforamen incisor was the most frequent cleft type; coronal was the most frequent velopharyngeal closure pattern; and that most of the studies indicated the diagnosis of borderline velopharyngeal closure.

Among the female patients, the coronal pattern of velopharyngeal closure was the most frequent, and among the male patients, the circular pattern followed by the coronal pattern (Table 2). However no relation was observed between gender and velopharyngeal closure pattern ($p=0.315$).

As regards age range and velopharyngeal closure pattern (Table 3), it was observed that, among the patients aged between four and eight years, most of them presented the coronal pattern of velopharyngeal closure; between nine and 12 years, the circular and coronal patterns were most frequently found; between 13 and 18 years, the circular pattern, and among those aged above 18, the coronal pattern was the most frequently found. However no relation was observed between age range and velopharyngeal closure pattern.

Among the patients with post-foramen incisor cleft, the coronal pattern was most frequently observed, followed by the circular pattern; and, among the patients with transforamen incisor cleft, the circular pattern was most frequently observed, followed by the coronal pattern (Table 4). However, no relation was observed between cleft type and velopharyngeal closure pattern.

As regards velopharyngeal function diagnosis, it is observed that, among the patients with adequate velopharyngeal closure, the sagittal closure pattern was most frequently observed (Table 5). On the other hand, the circular pattern was most frequently observed in the patients with borderline velopharyngeal closure; and the coronal pattern was most frequently present in the patients with inadequate velopharyngeal closure. There was a relation between velopharyngeal function diagnosis and the pattern of velopharyngeal closure.

Table 1. Variables, frequency in the sample and respective significance values

Variable	Frequency n (%)	p-value
Gender		
Female	53 (59.55)	0.045*
Male	36 (40.45)	0.964
Age range		
4-8 years	18 (20.22)	1.000
9-12 years	19 (21.35)	1.000
13-18 years	17 (19.10)	1.000
>18 years	35 (39.33)	0.983
Cleft type		
Post-foramen	40 (44.94)	0.855
Transforamen	49 (55.06)	0.198
Bilateral	17 (34.69)	0.989
Unilateral (right)	9 (18.37)	1.000
Unilateral (left)	23 (46.94)	0.716
Velopharyngeal closure pattern		
Coronal	33 (37.08)	0.995
Circular	30 (33.71)	0.999
Circular with Passavant's ridge	14 (15.73)	1.000
Sagittal	12 (13.48)	1.000
Velopharyngeal function diagnosis		
Adequate	13 (14.61)	1.000
Borderline	48 (53.93)	0.263
Inadequate	28 (31.46)	1.000

* Significant values ($p \leq 0.05$) – Chi-square test

Table 2. Relation between velopharyngeal closure and gender

Gender	Velopharyngeal closure pattern	Frequency n (%)
Female	Coronal	19 (35.85)
	Circular	15 (28.30)
	Circular with Passavant's ridge	11 (20.75)
	Sagittal	8 (15.09)
	Total	53 (100.00)
Male	Coronal	14 (38.89)
	Circular	15 (41.67)
	Circular with Passavant's ridge	3 (8.33)
	Sagittal	4 (11.11)
	Total	36 (100.00)
Total		89

Chi-square test ($p=0.315$)

DISCUSSION

The present study sample was constituted by a female majority. On the other hand, the literature reports a male prevalence in cases of cleft lip and palate in general and cleft lip, either with or without cleft palate, with a female prevalence

Table 3. Relation between velopharyngeal closure pattern and age range

Age range	Velopharyngeal closure pattern	Frequency n (%)	p-value
4 - 8 years	Coronal	8 (44.44)	0.760
	Circular	7 (38.89)	0.881
	Circular with Passavant's ridge	2 (11.11)	1.000
	Sagittal	1 (5.56)	1.000
	Total	18 (100.00)	-
9 -12 years	Coronal	6 (31.58)	0.968
	Circular	7 (36.84)	0.916
	Circular with Passavant's ridge	4 (21.05)	0.998
	Sagittal	2 (10.53)	1.000
	Total	19 (100.00)	-
13 - 18 years	Coronal	6 (35.29)	0.928
	Circular	9 (52.94)	0.500
	Circular with Passavant's ridge	1 (5.88)	1.000
	Sagittal	1 (5.88)	1.000
	Total	17 (100.00)	-
>18 years	Coronal	13 (37.14)	0.955
	Circular	7 (20.00)	1.000
	Circular with Passavant's ridge	7 (20.00)	1.000
	Sagittal	8 (22.86)	1.000
	Total	35 (100.00)	-
Total		89	-

Hypothesis test of proportions (p<0.05)

only in cases of isolated cleft palate⁽²⁴⁾. The absence of patients with isolated cleft lip in the present study sample may have influenced such aspect.

As far as the age range is concerned, it is observed that most of the patients in the present study sample were aged above 18 years. This can be explained by the fact that the unit of nasopharyngoscopy of the authors' institution was created in 2005, so many older patients who had already undergone surgery a long time ago and remained with symptoms of velopharyngeal dysfunction were referred for nasoendoscopic evaluation. Such a "restrained demand" may have had an

Table 4. Relation between velopharyngeal closure pattern and cleft type

Velopharyngeal closure pattern	Cleft type		
	Post-foramen n (%)	Transforamen n (%)	Total n (%)
Coronal	19 (57.58)	14 (42.42)	33 (100)
Circular	13 (43.33)	17 (56.67)	30 (100)
Circular with Passavant's ridge	5 (35.71)	9 (64.29)	14 (100)
Sagittal	3 (25.00)	9 (75.00)	12 (100)
Total	40 (44.94)	49 (55.06)	89 (100)

Chi-square test (p=0.197)

influence on the age of patients in the sample. It is expected that as time goes by most of the cases involve children aged up to 12 years.

In the present study, there was a predominance of patients with transforamen incisor cleft, a fact that is compatible with studies approaching the population of individuals with cleft lip and palate⁽²⁵⁾. No case of pre-foramen incisor cleft was observed, since this group of patients generally presents normal velopharyngeal function and therefore is not referred for nasopharyngoscopic evaluation that is the object of the present study.

Considering that in the present study many patients could not achieve an adequate velopharyngeal closure, the attempt or tendency towards closure was considered as a velopharyngeal closure pattern^(4,26). A coronal closure pattern was observed in most of the patients in the present sample. Studies developed with healthy individuals have demonstrated that the coronal pattern is also the one most frequently observed^(1,3,22,27), but the distribution of the other closure patterns among individuals with cleft palate tends to be wider^(3,4,26,27). Such findings might be related to a compensation generated by the velopharyngeal dysfunction itself⁽³⁾, either spontaneously developed or as a result of speech therapy.

Differences in the velopharyngeal closure patterns were observed in relation to the patients' age range. According to the literature, the physiology of the velopharyngeal mechanism presents differences depending on the age range, with relevant changes occurring during the first year of life, as the stomatognathic system becomes mature, changing the orofacial muscles functioning. Around the fourth year of life, along with the dental occlusion and the development of the face, the tongue develops within the intraoral space, reducing

Table 5. Relation between velopharyngeal closure pattern and velopharyngeal function diagnosis

Velopharyngeal closure pattern	Velopharyngeal function			Total n (%)
	Adequate n (%)	Borderline n (%)	Inadequate n (%)	
Coronal	2 (6.06)	17 (51.52)	14 (42.42)	33 (100)
Circular	3 (10.00)	20 (66.67)	7 (23.33)	30 (100)
Circular with Passavant's ridge	3 (21.43)	7 (50.00)	4 (28.57)	14 (100)
Sagittal	5 (41.67)	4 (33.33)	3 (25.00)	12 (100)
Total	13 (14.61)	48 (59.93)	28 (31.46)	89 (100)

Chi-square test (p=0.051)

anterior projections and no more directly interfering in the oropharyngeal space and velar movements, which may justify the absence of significant relation between velopharyngeal closure and age range⁽²⁸⁾.

Although in the present study most of the female patients have presented the coronal pattern of velopharyngeal closure and, among the male patients the circular pattern has been most frequently observed, the difference between genders was not significant. In studies utilizing radiological methods of evaluation, such a difference between genders has also not been observed in the physiology of the velopharyngeal mechanism for all the closure patterns and constriction degree⁽³⁾.

In the present study, no dependence was observed between cleft type and velopharyngeal closure pattern variables. In the literature, there is no study correlating such data, but the present results were already expected since cleft palate, either isolated or in association with cleft lip, equally affect the velopharyngeal function.

In the present study sample, the post-foramen incisor cleft was most frequently observed in the female patients, and the transforamen incisor cleft, in the male patients, a finding that is compatible with those reported in the literature^(24,25).

Among the patients with adequate velopharyngeal closure, the sagittal pattern was the most frequent, and the coronal pattern was the least frequently observed. Among the patients with borderline velopharyngeal closure, there was a prevalence of the circular pattern followed by the coronal pattern. Among the patients with inadequate velopharyngeal closure there was a prevalence of the coronal pattern. It is known that among

the general population the coronal closure pattern is most frequently found^(1,3,22,27).

It may be assumed that operated cleft palate patients presenting good pharyngeal wall mobility, like in the cases with circular closure pattern, can more easily achieve velopharyngeal closure due to compensation of the soft palate insufficiency. On the other hand, operated cleft palate patients with the coronal closure pattern would almost exclusively depend on the soft palate mobility to achieve velopharyngeal closure.

The findings of the present study may be useful to define the approach to be adopted as well as the prognosis for each individual case. Further prospective studies controlling the sessions periodicity, the patients' engagement and assiduousness, and particularly the adopted therapeutic focus, could investigate whether speech therapy can modify the velopharyngeal closure pattern by evaluating such a pattern both before and after a determined speech therapy period.

CONCLUSION

With the present study, the authors conclude that most of the patients in the sample presented coronal pattern of velopharyngeal closure, followed by the circular, circular with Passavant's ridge and sagittal patterns; and that no relation was observed between velopharyngeal closure pattern and the gender, age range and cleft palate type variables. The results indicate a relation between velopharyngeal closure pattern and velopharyngeal function diagnosis.

RESUMO

Objetivo: Caracterizar o padrão de fechamento velofaríngeo de pacientes operados de fissura palatina e sua relação com gênero, faixa etária, tipo de fissura e diagnóstico da função velofaríngea. **Métodos:** Estudo retrospectivo realizado a partir de 89 exames de nasofaringoscopia de pacientes operados de fissura palatina, entre 4 e 47 anos (média=17,32±10,50). Os dados foram analisados quanto ao gênero; faixa etária (4 a 8, 9 a 12 anos, 13 a 18 e acima de 18 anos); tipo de fissura (pós-forame e transforame); diagnóstico da função velofaríngea (adequada, marginal e inadequada) e padrão de fechamento velofaríngeo (coronal, circular, circular com prega de Passavant e sagital). Os resultados foram analisados estatisticamente. **Resultados:** Na amostra estudada, 59,55% eram do gênero feminino; 39,33% tinham mais de 18 anos de idade; 44,94% apresentavam fissura pós-forame e 55,06% transforame; 14,61% fechamento adequado, 53,93% marginal e 31,46% inadequado. Quanto ao padrão de fechamento, 37,08% apresentaram fechamento coronal, 33,71% circular, 15,73% circular com Passavant e 13,48% sagital. Houve relação do padrão de fechamento com o diagnóstico da função velofaríngea ($p=0,05$). **Conclusão:** A maior parte da amostra apresentou fechamento velofaríngeo coronal, seguido pelo circular, circular com Passavant e sagital. Não houve relação entre o padrão de fechamento e as variáveis gênero, faixa etária e tipo de fissura, mas observou-se influência relacionada ao diagnóstico da função velofaríngea.

Descritores: Fissura palatina; Nasofaringe; Palato mole; Insuficiência velofaríngea; Endoscopia

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