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Order of Consonant Production as a Predictor of Speech Outcomes After Primary Palatoplasty

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Background: Reliable early prediction of long-term speech outcomes after primary palatoplasty has not been explored. This study aimed to (1) clarify the relationship between the pattern of initial consonant production and postoperative speech outcome in patients with cleft palate (CP), and (2) investigate whether differences exist in the order pattern of initial consonant production by CP presence.
Methods: Consecutive children who underwent primary CP surgery between 2001 and 2016 at our hospital were retrospectively analyzed; 42 and 38 children were assigned to the CP and non-CP groups, respectively. The production order of the main Japanese consonants/k/,/g/,/t/, and/d/ was analyzed, and 3 groups were created: type td, where t/d precedes k/g; type kg, where k/g precedes t/d; and type same, where t/d and k/g occur simultaneously. We compared consonant patterns between groups and assessed the association between these patterns and the incidence of velopharyngeal insufficiency (VPI), abnormal articulations, and the need for additional treatment in the CP group.
Results: At both 4 and 7 years, the likelihood of having VPI was significantly higher in type kg children than in type td children. Velar consonants did not precede alveolar consonants in the non-CP group. Significantly more type kg patients received additional treatment than type td ($P < 0.001$) and type same ($P = 0.003$) groups.
Conclusions: Patients with normal velopharyngeal function acquired alveolar consonants (td) before velar consonants (kd), indicating that those who first produced velar consonants were more likely to present with VPI or require additional treatment.
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INTRODUCTION

Despite many studies on speech outcomes after cleft palate (CP) surgery, there are only a few reports on methods to predict the prognosis of speech outcomes,[1–3] and no effective methods have been adopted in clinical settings. Furthermore, there is a paucity of evidence regarding speech function associated with CP in non-English-speaking children.

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It is well known that velopharyngeal insufficiency (VPI) is a common cause of articulation errors. Once abnormal articulations are established, persistent training is required to correct them. However, such training is typically delayed until patients are 4 or 5 years old when they are developmentally ready for intervention. If poor language performance can be predicted, early intervention with speech therapy for the patient may prevent the development and fixation of abnormal articulations. Consequently, we initiated a study to observe the acquisition of consonants in children during their early developmental stages.

This study aimed to elucidate whether the "order of consonant production" is associated with VPI and abnormal articulation after primary palatoplasty. In addition, we examined whether the presence or absence of CP leads to a difference in consonant patterns from the beginning.

MATERIALS AND METHODS

Participants

The participants included in this study were patients with consecutive unilateral cleft lip and palate and cleft

Disclosure statements are at the end of this article, following the correspondence information.

lip and alveoli (UCLP, UCLA + CP) who underwent primary palatoplasty between 2001 and 2016 at the Department of Plastic Surgery, Tokai University Hospital (CP group). For comparison, a group of patients without CP was included in the study, comprising patients with consecutive unilateral cleft lip (UCL) and UCLA who underwent primary cheiloplasty (non-CP group). After excluding patients with syndromes with comorbid abnormalities, those who underwent orthodontic treatment at the age of 4 years or younger, and those who discontinued treatment due to a change in doctor, there were 42 patients in the CP group and 38 patients in the non-CP groups. Regarding the breakdown of cleft types, the CP group consisted of 37 UCLP and 5 UCLA + CP cases, whereas the non-CP group consisted of 20 UCLA and 18 UCL cases (Table 1).

Owing to the retrospective nature of the study, informed consent was not required; rather, an opt-out format was used. This study was approved by the institutional review board for clinical research, Tokai University (approval number 18R-102).

Data Source

Data were obtained from medical records for this retrospective and longitudinal study.

Methods of Speech Evaluation

A speech-language pathologist (SLP) in our department performed all the speech evaluations and recordings. Consonant acquisition by the children was evaluated and recorded every 3 months until the age of 4 years. Focusing on the main intraoral pressure-requiring consonants in Japanese, namely /k/, /g/, /t/, and /d/, we classified them into patterns in which:

1. /t/ and /d/ precede /k/ and /g/ (td-preceding type: type td),
2. /k/ and /g/ precede /t/ and /d/ (kg-preceding type: type kg),
3. they are produced at the same time (simultaneous type: type same).

Speech evaluation for the CP group was performed every 3 months from postpalatoplasty up to the age of 4 years and then every 6 months subsequently. Speech evaluation for children without CP (non-CP group) ended when all consonants were acquired. Velopharyngeal function (VPF) was classified into 4 stages (normal, mild VPI, moderate VPI, and severe VPI) based on auditory evaluation and nasal air leakage in the mirror test according to the Examination of Cleft Palate Speech of the Japanese Association of Communication Disorders.[4] To evaluate articulation, the presence or absence of glottal stops, palatalized articulation, lateralized articulation, and nasal emission, which are the representative abnormal articulations in Japanese, was evaluated and recorded.

Takeaways

Question: It is not currently possible to reliably predict long-term speech outcomes in patients with cleft palate (CP) in the early stages following primary palatoplasty.

Findings: This retrospective study of 42 children with CP and 38 controls found that the order in which children with CP acquired consonants was associated with velopharyngeal function.

Meaning: This indicates that speech outcomes can be predicted early and lead to targeted treatment.

Treatment Protocol at Our Facility

CP Group

Presurgical Orthodontics. The Hotz plate was fitted within 2 weeks of birth. Two months after birth, the cleft width was narrowed by using a Latham dentomaxillary appliance.[5]

Simultaneous Lip, Alveolar, and Palate Reconstruction. Simultaneous lip, alveolar, and palate closure surgery[6] were performed 6 months after birth. The mean surgery timing was 6.7 ± 1.4 months (range: 6–14 mo). Millard-type gingivoperiosteoplasty was performed for alveolar cleft reconstruction. The Furlow method (double opposing Z-plasty)[7] was utilized. These techniques allowed for consecutive reconstruction of the palate and alveolar ridge. Cheiloplasty was performed using the Millard rotation advancement technique and the small triangular flap method.[8,9]

Non-CP Group

Primary cheiloplasty was performed 3 months after birth, without presurgical orthodontics. The mean surgery timing was 3.3 ± 0.6 months. The surgical techniques used were the triangular flap method, the Millard method, and the small triangular flap method.

Statistical Analysis

EZR software[10] in combination with R (version 4.1.2; R Foundation for Statistical Computing, Vienna, Austria) was used for all statistical analyses. The Fisher exact test was used to compare consonant patterns between the CP and non-CP groups. The association among consonant patterns, VPF, and additional treatment was analyzed using the Steel-Dwass test on an ordinal scale, whereas the association between consonant patterns and articulation was analyzed using the Fisher exact test. The significance level was set at a *P* value less than 0.05.

Table 1. Overview of the Different Groups in the Current Study

Type of Cleft	UCLP	UCLA + CP	UCLA	UCL	Total
CP group	37	5	—	—	42
Non-CP group	—	—	20	18	38
					80

Endpoints

Comparison of Consonant Patterns Between Children With and Without CP

Consonant patterns were compared between CP group and non-CP group children.

Association Between Consonant Patterns and Speech Outcomes

We investigated the presence or absence of VPI and abnormal articulation in the CP group at the ages of 4 and 7 years longitudinally. Additionally, we examined the implementation of subsequent language-related treatments, including pharyngeal flap and articulation training. Furthermore, we evaluated the association between 3 consonant patterns and these speech outcomes.

RESULTS

Consonant Patterns

Non-CP Group

In the non-CP group, 26 (68.4%) children exhibited type td, 12 (31.6%) exhibited type same, and none exhibited type kg (Table 2).

CP Group

In the CP group, 24 (57.1%) children exhibited type td, 10 (23.8%) children exhibited type same, and 5 (11.9%) exhibited type kg. Additionally, 3 (7.1%) children produced glottal stops because of an inability to produce intraoral pressure-requiring consonants; thus, their order of consonants was unevaluable, and they could not be classified into 1 of the 3 patterns.

Comparison of Consonant Patterns Between Children With and Without CP

No statistically significant differences were observed between the 2 groups in consonant production patterns (Fig. 1). The non-CP group did not include any type kg or unevaluable children and consisted only of type td and type same children.

Speech Outcomes of the CP Group

Velopharyngeal Function

At the age of 4 years (Table 3), 33 (78.6%) children in the CP group had normal VPF, 6 (14.3%) had mild VPI, 2 (4.8%) had moderate VPI, and 1 (2.4%) had severe VPI. By the age of 7 years (Table 4), 27 (64.3%) children had normal VPF, 9 (21.4%) had mild VPI, 6 (14.3%) had moderate VPI, and none (0%) had severe VPI.

Articulation

At 4 years of age (Table 5), 38 (90.5%) children in the CP group had normal articulation. By the age of 7 years (Table 6), 37 (88.1%) children had normal articulation.

Table 2. Consonant Pattern According to the CP Status of Participants

Consonant Pattern	td, n (%)	Same, n (%)	kg, n (%)	Unevaluable, n (%)	Total
CP group	24 (57.1)	10 (23.8)	5 (11.9)	3 (7.1)	42
Non-CP group	26 (68.4)	12 (31.6)	0 (0)	0 (0)	38
Total	50 (62.5)	22 (27.5)	5 (6.25)	3 (3.75)	80

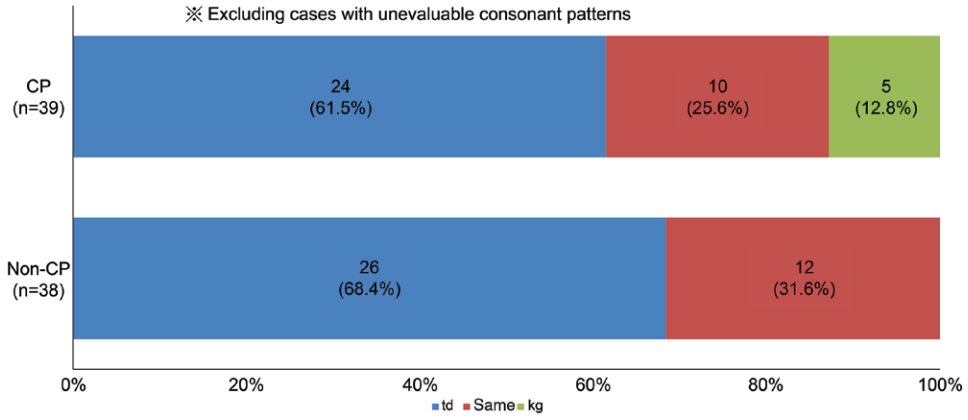

Fig. 1. Patterns of consonant production in infancy in the CP and non-CP groups. There are nonsignificant differences between the CP and non-CP groups (as determined by the Fisher exact test).

Table 3. VPF at 4 Years of Age

	td	Same	kg	Unevaluable	Total
Normal	23	8	2	0	33
Mild	1	2	3	0	6
Moderate	0	0	0	2	2
Severe	0	0	0	1	1
Total	24	10	5	3	42

Table 4. VPF at 7 Years of Age

	td	Same	kg	Unevaluable	Total
Normal	19	8	0	0	27
Mild	4	1	2	2	9
Moderate	1	1	3	1	6
Severe	0	0	0	0	0
Total	24	10	5	3	42

Table 5. Articulation at 4 Years of Age

	td	Same	kg	Unevaluable	Total
Normal	24	10	4	0	38
Glottal	0	0	0	3	3
Palatal/nasal emission	0	0	1	0	1
Palatal	0	0	0	0	0
Total	24	10	4	4	42

Table 6. Articulation at 7 Years of Age

	td	Same	kg	Unevaluable	Total
Normal	24	9	4	0	37
Glottal	0	0	0	3	3
Palatal/nasal emission	0	0	0	0	0
Palatal	0	1	1	0	2
Total	24	10	5	3	42

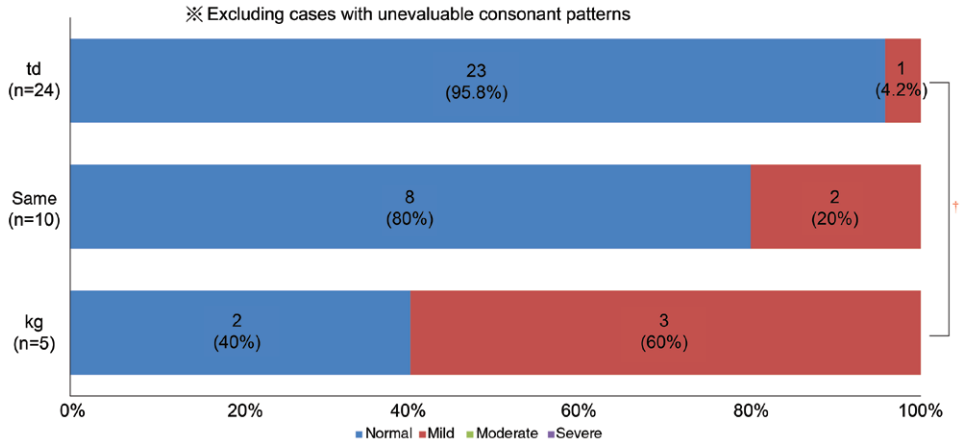

Fig. 2. Speech outcomes of CP: VPF (at 4 y of age). Analyzed as follows: (1) normal, (2) mild, (3) moderate, and (4) severe. †$P < 0.05$, Steel-Dwass test.

At 4 years, 4 (9.5%) children exhibited abnormal articulation, with 3 showing glottal stops and 1 showing palatalized articulation and nasal emission. At 7 years, 5 (11.9%) children exhibited abnormal articulation, with 3 showing glottal stops and 2 showing palatalized articulation.

Association Between Consonant Patterns and Speech Outcomes

Associations were examined after excluding 3 children with an unevaluable order of consonant production because of their inability to produce intraoral pressure-requiring consonants.

Is the Appearance of VPI in Children With CP Associated With Consonant Patterns?

At the age of 4 years, among the 24 children exhibiting type td, 23 (95.8%) had normal VPF, and 1 (4.2%) had mild VPI (Figs. 2, 3). Among the 10 children exhibiting type same, 8 (80%) had normal VPF, and 2 (20%) had mild VPI. In contrast, of the 5 children exhibiting type kg, 2 (40%) had normal VPF, and 3 (60%) had mild VPI. A statistically significant difference ($P = 0.003$) was observed in the VPF at the age of 4 years between the type td and type kg groups (Fig. 2).

At the age of 7 years, 19 (79.2%) children exhibiting type td and 8 (80.0%) children exhibiting type same had normal VPF. All children with type kg presented with VPI: none (0%) had normal VPF, 2 (40.0%) had mild VPI, and 3 (60.0%) had moderate VPI. Statistically significant differences in VPF at the age of 7 years were observed between type td and type kg ($P < 0.001$) and between type same and type kg ($P = 0.016$) (Fig. 3). Thus, at both 4 and 7 years, the percentage of VPI was significantly higher in type kg children than in type td children.

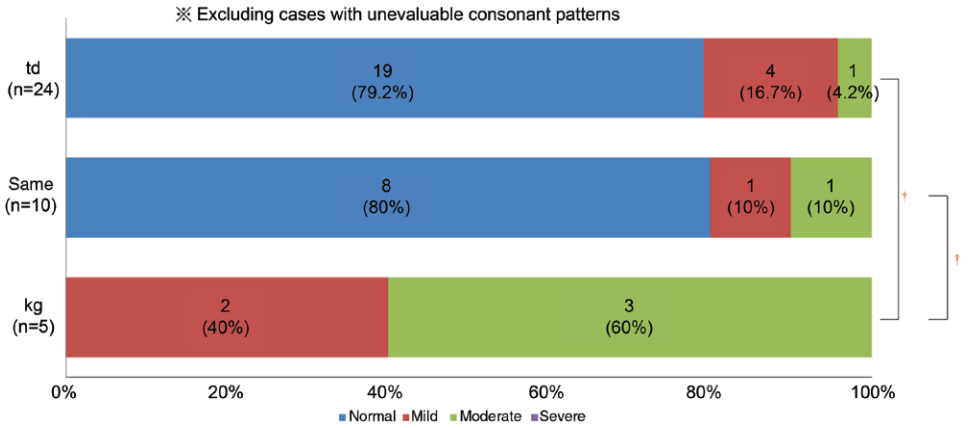

Fig. 3. Speech outcomes of CP: VPF (at 7 y of age). Analyzed as follows: (1) normal, (2) mild, (3) moderate, and (4) severe. †$P < 0.05$, Steel-Dwass test.

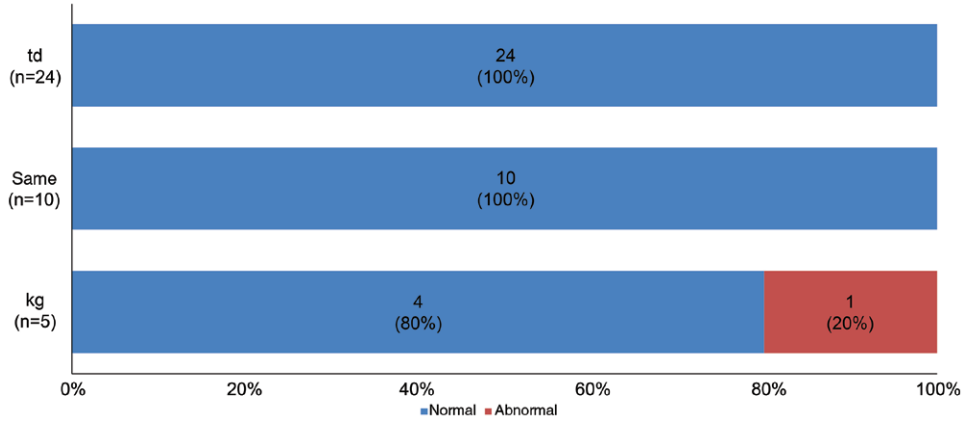

Fig. 4. Speech outcomes of CP: articulation (normal/abnormal) (at 4 y of age). There are nonsignificant differences between the groups (as determined by the Fisher exact test).

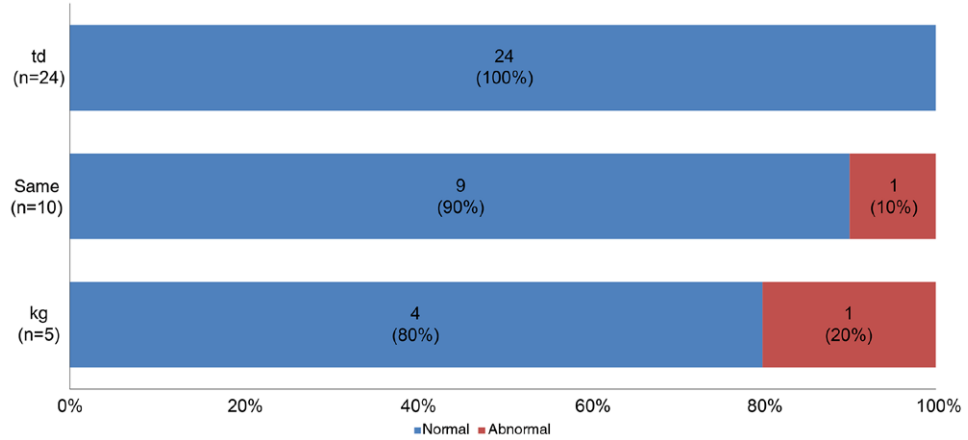

Fig. 5. Speech outcomes of CP: articulation (normal/abnormal) (at 7 y of age). There are nonsignificant differences between the groups (as determined by the Fisher exact test).

Is the Appearance of Abnormal Articulation in Children With CP Associated With Consonant Patterns?

At 4 years of age, 100% of the children exhibiting both type td (n = 24) and type td (n = 10) had normal articulation (Figs. 4, 5). Of the children with type kg (n = 5), 1 (20.0%) exhibited palatalized articulation and nasal emission (Fig. 4). At 7 years of age, all children with type td had normal articulations. One child with type same

Table 7. Additional Treatments Required for CP According to Consonant Patterns

	td	Same	kg	Unevaluable	Total
None	24	9	0	0	33
Pharyngeal flap/speech training	0	0	1	3	4
Speech training	0	1	4	0	5
Total	24	10	5	3	42

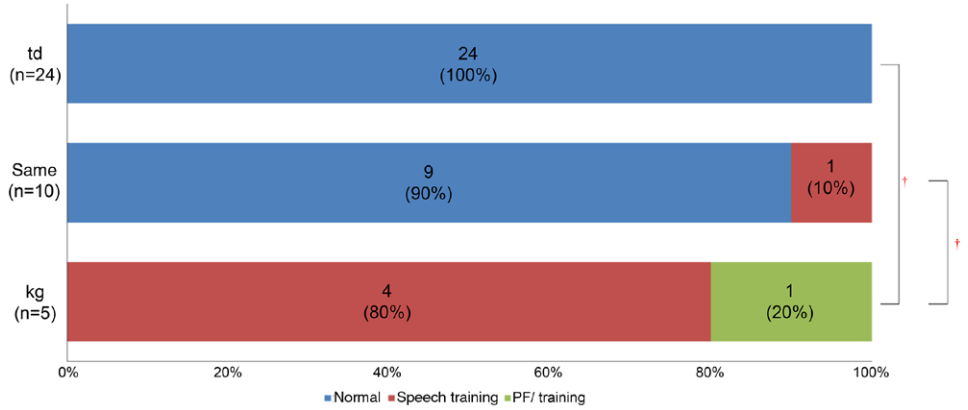

Fig. 6. Additional treatment for CP. Analyzed as follows: (1) normal, (2) speech training, and (3) PF/training. †$P < 0.05$, Steel-Dwass test.

(10.0%) and 1 child with type kg (20.0%) exhibited palatalized articulation (Fig. 5). No statistically significant difference was observed between consonant patterns in the incidence of abnormal articulation at ages 4 and 7 years.

Is There a Need for Additional Treatment of Children With CP Associated With Consonant Patterns?

None of the children with type td underwent additional speech-related treatment (Table 7 and Fig. 6). Of the entire CP group, 4 (9.5%) children underwent both pharyngeal flap surgery and articulation training; however, the order of consonant production was unevaluable in 3 children, and the remaining child exhibited type kg. Five (11.9%) children underwent articulation training only, 4 exhibited type kg, and 1 exhibited type same. Excluding children with unevaluable consonant patterns, significantly more children exhibiting type kg required additional treatment than those exhibiting type td ($P < 0.001$) or type same ($P = 0.003$).

DISCUSSION

Is the Precedence of Velar Consonants Associated With the Presence or Absence of CP?

In our study, children without CP exhibited only consonant patterns of either type td or type same and not type kg. In addition, in the CP group, a significantly high percentage of children exhibiting type kg presented with VPI at ages 4 and 7 years. These results imply that the appearance of type kg is associated with CP, which in turn is related to insufficient VPF.

Previous literature has reported that the acquisition of correct consonants is delayed in children with CP; a study related to the Swedish language showed that presurgical orthodontics was not associated with the number and type of consonants acquired by patients with UCLP, but was significantly less than that in healthy children.[11] In addition, the frequency of appearance of bilabial consonants and dental consonants was significantly higher in the healthy group than in the UCLP group.[11] The median percentage of correct consonants was 52% in 3-year-olds with CP and 79% in 3-year-olds without CP.[12] In addition, correct consonants were also reported to be 15%–30% less than those in 3-year-olds without CP.[3,13] None of these previous studies mentioned an association with VPF; however, the association between the expression of consonants and CP was suggested.

Reports on the timing of consonant acquisition in healthy children are limited. Winitz and Irwin[14] investigated meaningful words from the age of 12–18 months and reported that at the age of 13–14 months, bilabial consonants were the most common, followed by alveolar consonants, whereas velar consonants were the least common. At the age of 15–16 months, bilabial consonants were found to decrease, whereas alveolar and velar consonants increased. Consonants were also produced at approximately 17–18 months of age.

Factors Predicting Postoperative Speech Function of Patients With CP

No prior study has explored the acquisition order of velar and alveolar consonants in children with CP; however, Lohmander and Persson[12] reported a positive correlation between the frequency of alveolar plosives at 18 months of age and the consonant articulation accuracy rate at the age of 3 years. However, in the current study, the precedence of velar consonants was related to subsequent VPF but not subsequent articulation. To the best of

our knowledge, no prior report has evaluated the relationship between velar consonants and the VPI.

We believe that the reason why t/d acquisition is delayed in pediatric patients with VPI could be that high intraoral pressure is required for t/d sounds.[15] In normal children, t/d sounds, which can be articulated by only lifting the tongue without having to retract it, are acquired first; however, in pediatric patients with poor VPF, it is difficult to acquire the t/d sounds, which require high intraoral pressure; in this situation, k/g sounds, which can be articulated even with low intraoral pressure, are acquired first.

Previous studies have investigated the prognostic value of speech outcomes after palatoplasty. Lee et al[1] focused on 27 patients with various types of CP and retrospectively investigated the association between preoperative palatal morphology analyzed by low-dose facial 3-dimensional computed tomography and the results of a hypernasality test for consonants and vowels using a nasometer. Palatal arch height and a wide distance between the maxillary tuberosities, rather than cleft type and palate length, were found to be significantly poor prognostic factors for VPF.

According to Chapman,[2] plosive production at 9 and 13 months is significantly correlated with several consonant production measurements at 21 months. In addition, plosive utterances at 13 months are correlated with the mean length of utterances and word count at 39 months. Furthermore, consonant and word production at 21 months was correlated with consonant and word production at 39 months. Moreover, it seems easier to predict the prognosis of speech outcomes from postoperative than preoperative speech.[2] In contrast, Scherer et al[3] noted no correlation between consonant production and babbling measurements at 12 months and consonant production and vocabulary measurements at 30 months.

Based on these findings, close observation of patients early after palatoplasty, before articulation acquisition, and planning speech therapy interventions for patients with a predicted poor outcome could improve prognosis. Hardin-Jones et al[16] claimed that speech therapy within 13 months after primary palatoplasty leads to better pronunciation, showing the importance of early interventions.

In recent years, in our department, if a patient produces velar consonant k/g first, even if that articulation of k/g is correct, we suspect VPI and ask an SLP to begin intervention. We observe whether the patient can use a straw, blow a toy trumpet, puff out their cheeks, or blow saliva out of their lips. If the patient is unable to do any of these things, the SLP instructs parents to practice these things at home. If these actions do not improve, we consider additional surgery.

Association Between Early CP Surgery and Speech Outcomes

At our facility, primary palatoplasty is performed early on patients with UCLP at approximately 6 months of age where possible, which is believed to be associated with a lower risk of abnormal articulation at the age of 7 years. Evans and Renfrew[17] performed palatoplasty using the Wardill–Kilner V-Y technique and classified patients into groups of patients who underwent surgery before 8, 8–10, 11–13, and 14–30 months. The authors found that the incidence of hypernasality and articulation disorders was lower in those who underwent surgery before 8 months of age than in those in the other groups. In another study of 100 patients with cleft lip and palate, surgery was performed on the cleft lip within 48 hours after birth and on the CP within 16 weeks and no patient presented with speech hypernasality.[18]

Dorf and Curtin[19] compared speech outcomes between "early surgery" at age 5–12 months and "late surgery" at 12–27 months, finding speech outcomes significantly better in the former group. In addition, Chapman et al[20] stated that approximately 50% of infants produce standard babbling up to the age of 9 months; thus, palatoplasty should be performed within the first 6 months of life, suggesting an association between the presence of a cleft during the babbling acquisition period and subsequent abnormal articulation. Kaplan[21] claimed that the nervous system and muscle control have learning windows and that delayed palatoplasty leads to the acquisition of incorrect articulation patterns up to the age of 8–9 months, which continues postoperatively. Thus, many pediatric patients may acquire normal articulation when palatal closure is performed without difficulty within 6 months of age, ensuring that the palate is in a state close to normal, anatomically and functionally, before babbling.

This study is limited by its retrospective nature and small participant numbers. Large prospective interventional studies are necessary to confirm that early speech therapy interventions can positively alter the prognosis of children with CP.

In addition, as all the subjects in this study were native speakers of Japanese, it is difficult to determine whether the results of the study can be applied to other language speakers. However, the main problem for CP patients is VPI, and the mechanism that affects the production of intraoral pressure-requiring consonants is common in other languages. For this reason, the findings of this study can be replicated in any other language.

CONCLUSIONS

This study evaluated consonant production in children with CP and revealed that children with normal VPF acquire alveolar consonants (/t/ and /d/) before velar consonants (/k/ and /d/), and among the children who acquire velar consonants first, many have poor VPF or require postoperative additional treatment. Understanding consonant production in pediatric patients after primary palatoplasty allows therapeutic interventions for speech from an early stage, raising the possibility of improving the prognosis in this patient group.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author, U. Hanai, upon request.

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ETHICAL APPROVAL

This study was approved by the institutional review board for clinical research, Tokai University (approval number 18R-102).

REFERENCES

1. Lee JS, Kim JB, Lee JW, et al. Factors prognostic for phonetic development after cleft palate repair. *J Craniomaxillofac Surg.* 2015;43:1602–1607.
2. Chapman KL. Is presurgery and early postsurgery performance related to speech and language outcomes at 3 years of age for children with cleft palate? *Clin Linguist Phon.* 2004;18:235–257.
3. Scherer NJ, Williams AL, Proctor-Williams K. Early and later vocalization skills in children with and without cleft palate. *Int J Pediatr Otorhinolaryngol.* 2008;72:827–840.
4. Japanese Association of Communication Disorders. *Examination of Cleft Palate Speech.* Tokyo Interna Shuppan Co., Ltd; 2007.
5. Millard DR, Jr, Latham RA. Improved primary surgical and dental treatment of clefts. *Plast Reconstr Surg.* 1990;86:856–871.
6. Hanai U, Akamatsu T, Sakata N, et al. Speech outcomes of 10-year-old children after early palatoplasty using presurgical orthodontics at 6 months of age. *Tokai J Exp Clin Med.* 2018;43:168–172.
7. Furlow LT, Jr. Cleft palate repair by double opposing Z-plasty. *Plast Reconstr Surg.* 1986;78:724–738.
8. Millard DR, Jr. Refinements in rotation-advancement cleft lip technique. *Plast Reconstr Surg.* 1964;33:26–38.
9. Millard DR Jr. A small chapter on a millimeter modification In: Millard DR, Jr, ed. *Cleft Craft: the Evolution of Its Surgery—Volume I: The Unilateral Deformity.* 1st ed. Hagerstown, MDLittle Brown and Company; 1976:419–424.
10. Kanda Y. Investigation of the freely available easy-to-use software "EZR" for medical statistics. *Bone Marrow Transplant.* 2013;48:452–458.
11. Lohmander A, Lillvik M, Friede H. The impact of early infant jaw-orthopaedics on early speech production in toddlers with unilateral cleft lip and palate. *Clin Linguist Phon.* 2004;18:259–284.
12. Lohmander A, Persson C. A longitudinal study of speech production in Swedish children with unilateral cleft lip and palate and two-stage palatal repair. *Cleft Palate Craniofac J.* 2008;45:32–41.
13. Chapman KL, Hardin-Jones MA, Goldstein JA, et al. Timing of palatal surgery and speech outcome. *Cleft Palate Craniofac J.* 2008;45:297–308.
14. Winitz H, Irwin OC. Syllabic and phonetic structure of infants' early words. *J Speech Hear Res.* 1958;1:250–256.
15. Subtelny JD, Worth JH, Sakuda M. Intraoral pressure and rate of flow during speech. *J Speech Hear Res.* 1966;9:498–518.
16. Hardin-Jones M, Chapman KL, Heimbaugh L, et al; Cleft Outcomes Research NETwork (CORNET) Consortium. Stop consonant production in children with cleft palate after palatoplasty. *Cleft Palate Craniofac J.* 2024;61:1087–1095.
17. Evans D, Renfrew C. The timing of primary cleft palate repair. *Scand J Plast Reconstr Surg.* 1974;8:153–155.
18. Desai SN. Early cleft palate repair completed before the age of 16 weeks: observations on a personal series of 100 children. *Br J Plast Surg.* 1983;36:300–304.
19. Dorf DS, Curtin JW. Early cleft palate repair and speech outcome. *Plast Reconstr Surg.* 1982;70:74–81.
20. Chapman KL, Hardin-Jones M, Schulte J, et al. Vocal development of 9-month-old babies with cleft palate. *J Speech Lang Hear Res.* 2001;44:1268–1283.
21. Kaplan EN. Cleft palate repair at three months? *Ann Plast Surg.* 1981;7:179–190.