International Journal of Speech-Language Pathology

ISSN: 1754-9507 (Print) 1754-9515 (Online) Journal homepage: https://www.tandfonline.com/loi/iasl20

Tongue-palate contact patterns for Japanese speakers with and without cleft lip and palate

Ichiro Yamamoto

To cite this article: Ichiro Yamamoto (2019): Tongue-palate contact patterns for Japanese speakers with and without cleft lip and palate, International Journal of Speech-Language Pathology, DOI: 10.1080/17549507.2019.1593505

To link to this article: https://doi.org/10.1080/17549507.2019.1593505

Published online: 23 Apr 2019.

images demonstrated the wide degree of intra- and inter-participant variability for productions of each sound, they showed the essential contact (100%) and contact-free electrodes (0%), from which the basic configuration of tongue-palate contact pattern was observed. Following the method of McLeod and Roberts (2005), a cumulative pattern was generated from EPG recordings of five typical Japanese-speaking adults (Fujiwara, Yamamoto, & Maekawa, 2008). This time, we refined the typical tongue-palate contact patterns by adding EPG recordings of 10 typical speakers, a total of 15 typical speakers served as control group. However, it is questionable whether these target patterns are adequate for clients with repaired unilateral cleft lip and palate (UCLP), as their dento-palatal morphology is different from that of normal participants (Šmahel, Trefný, Formánek, Mullerova & Peterka, 2004). Hardcastle and Gibbon (1997) stated that "it is not simple to define what a 'normal' spatial pattern would be for these speakers, and likewise what would constitute a spatial distortion" (p. 173).

Several studies investigated the relationship between palate shape and articulatory behaviour via EPG and acoustic analysis (Brunner, Fuchs, & Perrier, 2009; Weirich & Fuchs, 2013). However, their participants were typical speakers without cleft palate. To our knowledge, there is little report on tongue-palate contact patterns of the clients with repaired cleft lip and palate whose speech sounds were perceived as correct. Most previous EPG studies reported the error contact patterns observed in speakers with repaired cleft palate during speech and compared the findings to those observed in individuals with typical craniofacial structures but very little compared the contact patterns in speakers with repaired cleft palate for speech sounds that were perceived as correct to those demonstrated in typical controls.

The research question of this study was to investigate whether there were differences in tongue-palate contact patterns between typical speakers with and without UCLP. For this purpose, EPG cumulative images for Japanese consonants were generated and compared between the participants with repaired UCLP and typical Japanese speakers without cleft lip and palate.

Method

Participants

The participants were 15 clients with repaired UCLP who had been recruited for this study from outpatients at our clinic. As a control, 15 individuals with typical craniofacial structures participated. After obtaining clients' consent, their speech was recorded; speech materials were words and sentences, including every Japanese consonant. Perceptual assessment of speech was performed separately by five experienced speech-language pathologists; only the clients whose speech was evaluated as normal by five speech-language pathologists were enrolled in this study. Nine females and six males were included; the age range was 14.83–34.42 years, with an average of 20.75 years (Table I).

The surgical and orthodontic treatment histories of the participants and their present dental conditions (dental development stage, incisal classification, skeletal patterns, shape of the maxillary arch, and palatal height) are shown in Table I. The Dental Development Stage was classified in accordance with the rules of Hellman's classification (Hellman 1932). One case was categorised as IIIC (Eruptive phase of permanent second molar), six cases as IVA(Eruption of permanent second molar completed), five cases as IVC(Eruptive phase of permanent third molar) and three cases as VA (completion of permanent occlusion)

Table I. Participants' clinical features and oral conditions.

ID	Sex	Age (y;m)	Cleft type	Age at Cheiloplasty	Age at Palatoplasty	Age at alveolar bone graft	Orthodontics	Dental development stage	Incisal classification	Skeletal pattern	Arch form	Palatal height (mm)
1	M	14;10	L-UCLP	3m	1;6	8;5	Expansion plate	IVA	I	1	U	20.1
2	M	17;7	L-UCLP	3m	1;3	8;9	Retainer	IVA	I	1	U	14.5
3	M	20;3	L-UCLP	3m	1;6	9;5	Retainer	IVC	III	3	U	12.4
4	M	21;1	L-UCLP	3m	1;2	8;6	Retainer	IVC	I	1	U	19.7
5	M	16;7	R-UCLP	3m	1;5	7;9	Multi-bracket	IVA	I	2	U	18.1
6	M	18;4	R-UCLP	3m	1;5	9;1	Retainer	IVC	I	3	U	14.0
7	M	19;2	R-UCLP	4m	1;7	8;11	Retainer	IVA	I	1	U	10.5
8	M	21;11	R-UCLP	4m	1;1	10;4	Retainer	IVC	I	3	U	14.7
9	M	23;11	R-UCLP	3m	1;6	8;6	Retainer	IVC	I	3	U	18.9
10	F	14;3	L-UCLP	3m	1;11	10;2	Multi-bracket	VA	I	3	U	17.3
11	F	14;8	L-UCLP	3m	1;4	7;3	Retainer	IIIC	I	1	V	12.4
12	F	19;8	L-UCLP	4m	1;6	11;0	Retainer	IVA	I	2	U	21.4
13	F	20;6	L-UCLP	4m	1;5	12;0	Retainer	IVA	I	1	U	13.7
14	F	23;7	L-UCLP	3m	1;9	9;3	Retainer	VA	III	3	U	20.8
15	F	34;5	L-UCLP	3m	1;6	28;2	Retainer	VA	I	1	Saddle	9.3

M: male; F: female; y: year; m: month; UCLP: unilateral cleft lip and palate; R: right; L: left; IVA: eruption of permanent second molar completed; IVC: eruptive phase of permanent third molar; VA: completion of permanent occlusion; IIIC: eruptive phase of permanent second molar (Hellman, 1932); Class I: the lower incisor tips occlude or lie below the cingulum plateau of the upper incisors; Class III: the lower incisor tips occlude or lie anterior to the cingulum plateau of the upper incisor (Angle, 1889); Skeletal 1: normal anteroposterior relationship of the dental base; Skeletal 2: the mandibulardental base is postnormal relative to the maxillary dental base; Skeletal 3: the mandibular dental base is prenormal relative to the maxillary dental base (Ballard, 1951); U: U-shaped; V: V-shaped; Saddle: Saddle-shaped.

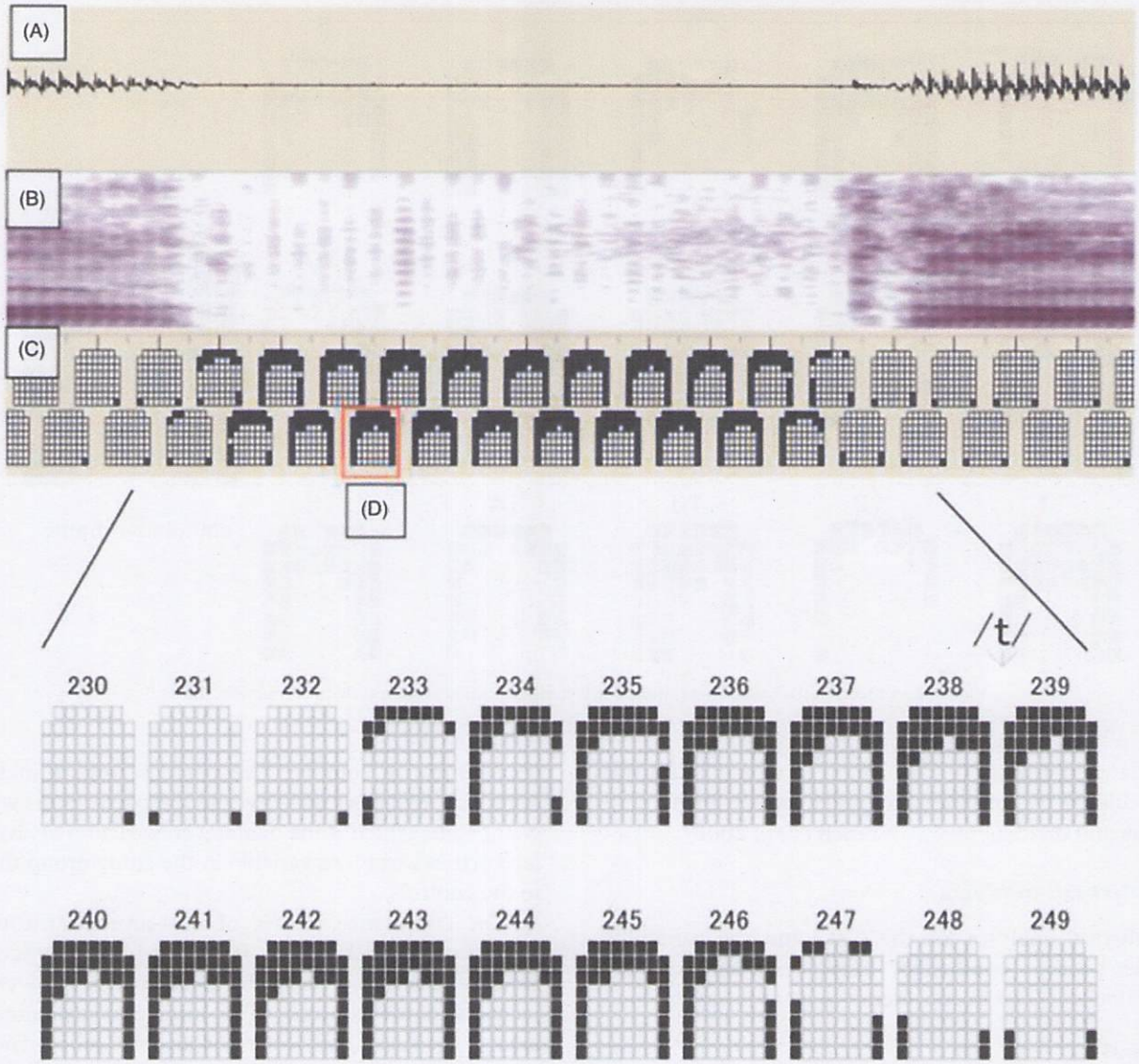

Figure 1. Analysis screen of normal [ata] and enlarged EPG consecutive pattern. A: sound wave; B: sound spectrogram; C: EPG consecutive pattern; D: the maximum contact frame (238).

level of accuracy (95%) between the researcher and the collaborator for the identification of the maximum point of contact.

The maximum contact frames for the target consonant for all participants were aggregated, using the filter function of AA. Figure 2 shows the 15 participants' maximum contact EPG frames of/t/and their cumulative frame. A darker frame indicated more frequent electrode contact. The number on each electrode showed the percentage of tongue contact to that particular electrode. One hundred per cent indicated that the electrode was contacted by every participant; in contrast, zero per cent indicated that the electrode was never contacted by any participant.

Analysis measures

Centre of gravity (CoG) value

Centre of gravity expressed the location of the main concentration of activated electrodes across the palate. The calculation assigned progressively higher values towards the more anterior row (Hardcastle & Gibbon, 1997).

$$CoG = \frac{\left(\begin{array}{c} 7.5R_1 + 6.5R_2 + 5.5R_3 + 4.5R_4 + 3.5R_5 \\ +2.5R_6 + 1.5R_7 + 0.5R_8 \end{array}\right)}{Total\ number\ of\ contacts}$$

Variability index value

Variability index was defined as a value to indicate the stability/variability of articulatory gestures. To calculate the index, the per cent frequency of activation of each contact was measured across repetitions. For each contact, 100% and 0% activation frequency represented invariance and were assigned a variance index of 0. The variability index increased as contact frequency approached 50%, which was assigned a

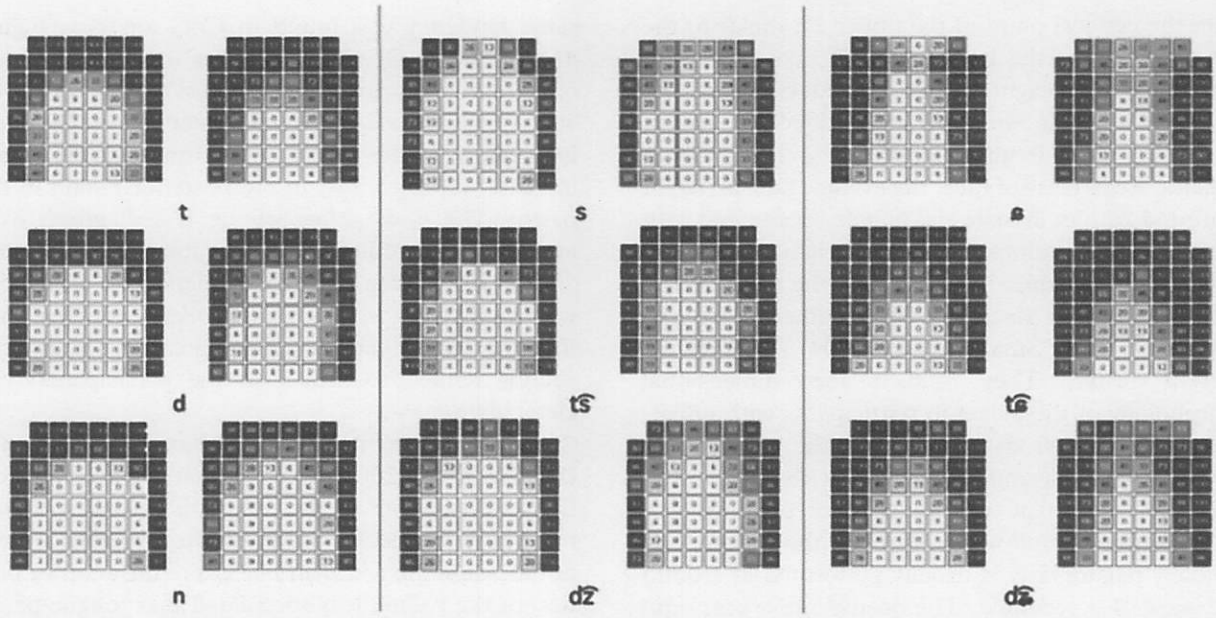

Figure 3. Cumulative patterns for each consonant [t, d, n, s, ts, dz, ɕ, t͡ɕ, d͡ʑ]. The control group are presented on the left and the unilateral cleft lip and palate (UCLP) group on the right.

Variability index

Figure 4(B) shows the average variability index for each consonant in the control group (filled column) and the UCLP group (open column). In every sound, the variability index was higher in the UCLP group. In/n/, the average variability index was higher in the UCLP group. Student's *t*-test revealed no statistically significant difference between the UCLP group and the control group.

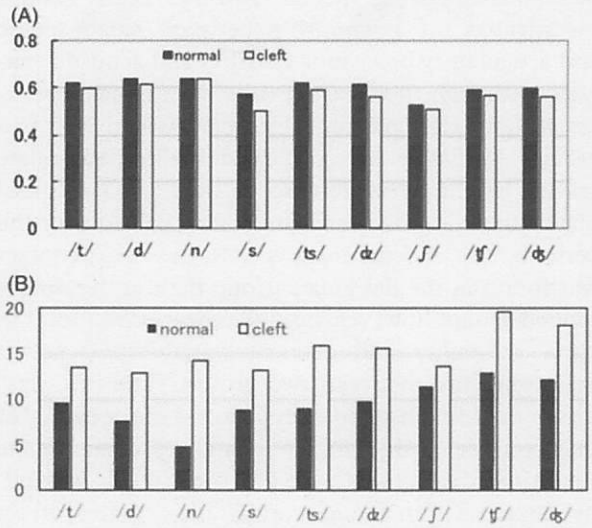

Figure 4. Comparison of analysis measures in each consonant between the unilateral cleft lip and palate (cleft) and the control group (normal). (A) Comparison of centre of gravity for the control group (filled column) and UCLP group (open column). (B) The average variability index for each consonant in the control group (filled column) and UCLP group (open column).

Discussion

The aim of the current study was to investigate whether there were any differences of tongue-palate contact patterns, during the production of alveolar and post-alveolar consonants, between typical speakers with and without cleft lip and palate. Because of the different dento-palatal morphology after the repair of cleft lip and palate, it is hypothesised that tongue-palate contact patterns of the clients might be different from those of the typical speakers without cleft. In order to verify this hypothesis, EPG cumulative images for Japanese consonants were generated and compared between the study group and the control group who had not demonstrated cleft lip and palate.

The measurement of dental conditions revealed that the participants with repaired cleft lip and palate showed various types of occlusion, arch form of the dental arches, palatal height, spacing among the maxillary anterior teeth, congenitally missing maxillary anterior tooth, and ectopic teeth on the palate. As the clients had undergone orthodontic and prosthodontic treatment by that time, no severe maxillary arch and occlusion were observed. However, the average palatal height of the study group was 15.9 mm in male clients (range: 14.0–20.1 mm) and 15.8 mm in female clients (range: 9.3–20.8 mm). These were lower than the average palatal heights of the populations without cleft lip and palate. Thilander (2009) studied the palatal height of the Swedish population and reported an average of 20.5 mm in males and 19.7 mm in females at the age of 16. Koike (1985) reported on the palatal height of Japanese participants, 18–30 years old, with normal occlusion: the average height was 14.0 mm in males and 13.1 mm in females. In his study, the palatal height was measured

palatal morphology has been improved through orthodontic treatment.

Acknowledgments

The author would like to sincerely thank Y. Fujiwara, Ph.D. visiting professor at Osaka Health Science University for help with data collection and manuscript editing. I also would like to thank the participants of this study for their collaboration. In addition, I offer special thanks to Dr. Alan Wrench for his technical support.

Declaration of interest

The author reports no declarations of interest.

References

Angle, E.H.. (1889). Classification of malocclusion. *Dent Cosmos, 41*, 248.

Ballard, C.F. (1951). Recent work in Noth America as it affects orthodontic diagnosis and treatment. *The Dental Record, 1 71*, 85.

Brunner, J., Fuchs, S., & Perrier, P. (2009). On the relationship between palate shape and articulatory behaviour. *Journal of the Acoustical Society of America, 125*, 3936–3949. doi: 10.1121/1.3125313

Cheng, H.Y., Murdoch, B.E., Goozee, J.V., & Scot, D. (2007). Electropalatographic assessment of tongue-to-palate contact patterns and variability in children, adolescents, and adults. *Journal of Speech, Language, and Hearing Research, 50*, 375–392. doi:10.1044/1092-4388(2007/027)

Fujiwara, Y. (2007). Eletropalatography home training using a portable training unit for Japanese children with cleft palate. *Advances in Speech-Language Pathology, 9*, 65–72. doi: 10.1080/14417040601120904

Fujiwara, Y., Yamamoto, I., & Ishimaru, M. (2008). Clinical features of the clients with cleft palate who underwent EPG visual feedback training: Abnormal EPG patterns and their perceptual impressions. *Abstract of the 5th International EPG Symposium*, 12.

Fujiwara, Y., Yamamoto, I., & Maekawa, K. (2008). EPG target pattern and quantitative analysis criteria for Japanese sounds –Aiming at clinical use of EPG. *The Japan Journal of Logopedics and Phoniatrics, 49*, 101–106. doi:10.5112/jjlp.49.101

Hardcastle, W.J., & Gibbon, F. (1997). Electropalatography and its clinical applications. In M. J. Ball & C. Code (Eds.), *Instrumental Clinical Phonetics* (pp. 173). London: Whurr Publishers.

Hellman, M. (1932). An introduction of growth of the human face from infancy to adulthood. *International Journal of Orthodontia Oral Surgery and Radiography, 18*, 777–798. doi: 10.1016/S0099-6963(32)90114-8

Koike, T. (1985). A morphological study on the palate -with particular reference to gnathofacial relationship. *Journal of Japanese Orthodontics, 44*, 201–221.

McLeod, S., Roberts, A., & Sita, J. (2006). Tongue/palate contact for the production of/s/and/z/. *Clinical Linguistics and Phonetics, 20*, 51–66. doi:10.1080/02699200400021331

McLeod, S., & Searl, J. (2006). Adaptation to an electropalatograph palate: Acoustic, impressionistic, and perceptual data. *American Journal of Speech-Language Pathology, 15*, 192–206. doi:10.1044/1058-0360(2006/018)

McLeod, S., & Singh, S. (2009). *Speech sounds: A Pictoral Guide To Typical And Atypical Speech*. San Diego, CA: Plural Publishing.

McLeod, S. & Roberts, A. (2005). Templates of tongue/palate contact for speech sound intervention. In *Proceedings of the 2005 Speech Pathology Australia National Conference*, (pp. 104–112).

Michi, K., Yamashita, Y., Imai, S., Suzuki, N., & Yoshida, H. (1993). Role of visual feedback treatment for defective /s/ sounds in patients with cleft palate. Journal Of Speech And Hearing Research, *36*, 277–286. doi:10.1044/jshr.3602.277

Peterson-Falzon S. J., Trost-Cardamone J., Karnell M. P., & Hardin-Jones M. A. (2006). *The Clinician's Guide To Treating Cleft Palate Speech*. Philadelphia: Mosby Elsevier.

Sell, D., Harding, A., & Grunwell, P. (1999). GOS.SP.ASS.'98: Assessment for speech disorders associated with cleft palate and/or velopharyngeal dysfunction (revised). International *Journal of Language and Communication Disorders, 34*, 17–33.

Šmahel, Z., Trefný, P., Formánek, P., Mullerova, Z., & Peterka, M. (2004). Three-dimentional morphology of the palate in subjects with unilateral complete cleft lip and palate at the stage of permanent dentition. *Cleft Palate-Craniofacial Journal, 41*, 416–423. doi:10.1597/03-053.1

Thilander, B. (2009). Dentoalveolar development in subjects with normal occlusion. A longitudinal study between the age of 5 and 31 years. *European Journal of Orthodontics, 31*, 109–120. doi:10.1093/ejo/cjn124

Weirich, M., & Fuchs, S. (2013). Palatal morphology can influence speaker-specific realization of phoneme contrasts. *Journal of Speech, Language, and Hearing Research, 56*, 1894–S1903. doi:10.1044/1092-4388(2013/12-0217)

Willadsen, E., Lohmander, A., Persson, C., Lundeborg, I., Alaluusua, S., Aukner, R., ... Semb, G. (2017). Scandcleft randomised trials of primary suregery for unilateral cleft lip and palate: 5. Speech outcomes in 5-year-olds-consonant proficiency and errors. *Journal of Plastic Surgery Hand Surgery, 51*, 38–51. doi:10.1080/2000656X.2016.1254647

Wrench, A.A., Gibbon, F.E., McNeill, A.M., & Wood, S.E. (2002). An EPG therapy protocol for the remediation and assessment of articulation disorders. In J.H.L. Hansen & B. Pellom (Eds.), *Proceeding of ICSLP-2002* (pp. 965–968), Denver, USA.

Yamada, Y., Murata, N., & Oka, T. (1988). A new speech training system for profoundly deaf children. *The Journal of the Acoustical Society of America, 84*, S43. doi:10.1121/1.2026312

Yamashita, Y., & Michi, K. (1991). Misarticulation caused by abnormal lingual-palatal contact in patients with cleft palate with adequate velopharyngeal function. *Cleft Palate Craniofacial Journal, 28*, 360–366. doi:10.1597/1545-1569(1991)028<0360:MCBALP > 2.3.CO;2