The association between dental arch dimensions and occurrence of Finnish dental consonant misarticulations in cleft lip/palate children

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The aim of this study was to examine whether maxillary and mandibular dental arch width, length, and palatal height dimensions are associated with the occurrence of misarticulations (phonetic or phonologic errors) in the dental consonants /r/, /s/, and /l/ in different cleft types and sexes. The subjects were 263 (109 girls, 154 boys) 6-year-old Finnish-speaking non-syndromic children with isolated cleft palate (CP, $n = 79$), cleft lip/alveolus (CL(A), $n = 77$), unilateral (UCLP, $n = 80$), and bilateral (BCLP, $n = 27$) cleft lip and palate. Dental plaster casts were measured by two authors using the technique of Moorrees, and auditive speech was analyzed with high reliability by two speech pathologists. The results showed that the occurrence of misarticulations increased and dental arch dimensions decreased with the severity of the cleft. Narrower and shorter maxillary arches as well as shallower palates were related to problems with the studied dental consonants. Mandibular arch dimensions were not related to the misarticulations. However, statistical analysis did not reveal significant differences in dental arch dimensions between subjects with and without misarticulations when they were compared separately for different cleft types. The etiology of clefting per se—isolated cleft palate versus cleft lip with or without cleft palate—did not seem to explain the associations between dental arch dimensions and the studied misarticulations. □ *Cleft palate; dentition; speech disorders*

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Velopharyngeal adequacy, hearing, intelligence, age, early speech patterns, and motivation are known to affect speech particularly in subjects with cleft palates. Their speech abilities are reported to be inferior to those of healthy subjects, and they have been stated to misarticulate frequently the dental consonants /r/, /s/, and /l/ (1–3). In Finnish 6-year-old cleft children, 44% had at least one misarticulation of these sounds (4), the most common being /r/-errors (36%), followed by /s/- (23%) and /l/-errors (18%). Nearly 10% of Finnish non-cleft school-children have /r/-disorders, and 30% have /s/-disorders (5, 6).

Large clefts are found to be associated with more defective speech (4, 7, 8) and smaller maxillary dento-alveolar dimensions (9). Maxillary arch width and length dimensions at different ages have both been found to be smaller in children with clefts than in non-cleft subjects (8, 10). The factors causing misarticulations of dental sounds are not yet fully understood, but size and shape of the oral cavity are suggested to affect pronunciation (11, 12) by influencing the functions and relations of the tongue as well as those of the soft palate (13), and the position of the tongue and hyoid bone (14). The aim of this study was to examine whether maxillary and mandibular dental arch width, arch length, and palatal height dimensions are associated with the occurrence of misarticulations of the dental consonants /r/, /s/, and /l/ in different cleft types and sexes.

Materials and methods

Subjects

The patients in the present study were treated at the Cleft Centre, Department of Plastic Surgery, Helsinki University Central Hospital. They participated in routine follow-up examinations at the age of 6 years, when dental plaster casts, cephalograms, and speech analysis were made. The patients' records were reviewed for cleft type and extent, primary and secondary surgery, syndromes and associated anomalies, and speech analyses. Only patients with acceptable plaster casts of maxillary and mandibular dentitions and patients with normal hearing without any known syndrome or associated anomaly possibly affecting speech or psychomotor retardation were included in the study group. The subjects with acceptable dental plaster casts comprised 263 (109 girls, 154 boys) of 280 consecutive Finnish-speaking Caucasian 6-year-old children with clefts born in 1980–88, with the years varying in different cleft types. The mean age at the routine follow-up examination was 6.1 years (standard deviation (s) = 0.2 years; range, 5.6–7.2 years). The distribution of subjects by the type of cleft, sex, and occurrence of misarticulations is shown in Table 1. The cleft palate was closed at the mean age of 1.4 years ($s = 0.4$; range, 0.8–2.1 years) using one-stage closure (15). None of the subjects had had orthodontic treatment.

Dental arch measurements

The dimensions of maxillary and mandibular dental arches were measured on dental casts using the method described by Moorrees (16), and the palatal height was measured as described by Nyström & Ranta (10). The maxillary and mandibular intermolar arch widths were measured between the first deciduous molars and the second deciduous molars. The measurements were done by two of the authors with a sliding digital calipers (MITUTOYO) to the nearest tenth of a millimeter. Double measurements were done on bilateral cleft lip and palate (BCLP) patients ($n = 27$) by the same authors, with a 2-month interval. The analysis of variance by Winer (17) showed high inter- and intrajudge reliability (in arch width and length dimensions, $r^2 = 0.96–1.00$; in palatal height dimensions, $r^2 = 0.82–0.98$).

Speech analysis

Auditive analysis of speech was made by one of the two experienced speech pathologists on the team. Misarticulations (phonetic or phonologic errors) of the dental sounds /r/, /s/, and /l/ were evaluated in spontaneous speech and categorized into correct, distorted, and substituted sounds. To ensure that the interpretations by our two speech pathologists of the speech data in hospital records were identical, interjudge agreement was assessed by having each patient's /r/-, /s/-, and /l/-values checked at the same time by both speech pathologists, and the categorizing of distortions and substitutions was based on a 100% consensus between them. The procedure and detailed methods of speech analysis have been described elsewhere (4).

Statistical methods

The data were analyzed using Student's t test, the Mann–Whitney U-test, and version 6.0 of the NCSS for Windows. Probabilities of less than 0.05 were considered significant.

Results

Dental arch dimensions

Fig. 1 shows comparisons of maxillary dental arch dimensions for 6-year-old non-cleft children (10) and the cleft groups. In general, statistically significant differences were found between the sexes (range of P values, 0.000–0.648) for both maxillary and mandibular dental arch dimensions and for different cleft types. Boys had larger values in all dimensions in each cleft group. Maxillary widths decreased with the severity of the cleft, while maxillary length and palatal height as well as mandibular dental arch dimensions were less influenced. Cleft lip/alveolus (CL(A)) children had the widest dimensions, and BCLP children the narrowest. Compared with the non-cleft group, the cleft children had maxillary dimensions that were clearly smaller than the mandibular ones.

Misarticulations of one or more of the studied sounds by sex

Table 2 shows statistical comparisons of the mean values of the maxillary dental arch dimensions between subjects misarticulating one or more of the sounds /r/, /s/, and /l/ and subjects without misarticulations. In general, both boys and girls with sound errors had significantly narrower maxillary dental arches than subjects without errors. In addition, girls with /r/-, /s/-, and /l/-errors had significantly shallower palates than girls without errors. Boys with /s/- and /l/-errors and girls with /r/-errors also had significantly shorter maxillary dental arches than subjects without errors. Fig. 2 presents the occurrence of /r/-, /s/-, and /l/-errors with their combinations in the smallest (<25%) and biggest (>75%) quartiles of the maxillary dental arch dimensions separately for boys and girls. The occurrence of all studied sound errors exceeded the expected 25% in all maxillary dental arch dimensions in both boys and girls in the smallest quartiles. Correspondingly, in the biggest quartiles there were very few subjects with the misarticulations studied. Only one mandibular dental arch dimension differed significantly

Table 1. Number of subjects (109 girls, 154 boys) with and without misarticulations, separately for /r/, /s/, and /l/ and their combinations, by type of cleft and by sex

		No. of subjects with /r/-, /s/-, or /l/-misarticulation or their combinations (Comb.)												No. of subjects without any studied misarticulation		
		Boys				Girls				Total						
Cleft*	n	/r/	/s/	/l/	Comb.	/r/	/s/	/l/	Comb.	/r/	/s/	/l/	Comb.	Boys	Girls	Total
CP	79	12	5	8	16	11	6	3	14	23	11	11	30	19	30	49
CL(A)	77	14	5	5	14	1	1	1	2	15	6	6	16	32	29	61
UCLP	80	30	27	14	37	8	3	4	10	38	30	18	47	16	17	33
BCLP	27	11	8	6	13	6	4	5	7	17	12	11	20	7	0	7
Total	263	67	45	33	80	26	14	13	33	93	59	46	113	74	76	150

* CP = subjects with cleft palate only; CL(A) = subjects with cleft lip with or without cleft alveolus; UCLP = subjects with unilateral cleft lip and palate; BCLP = subjects with bilateral cleft lip and palate.

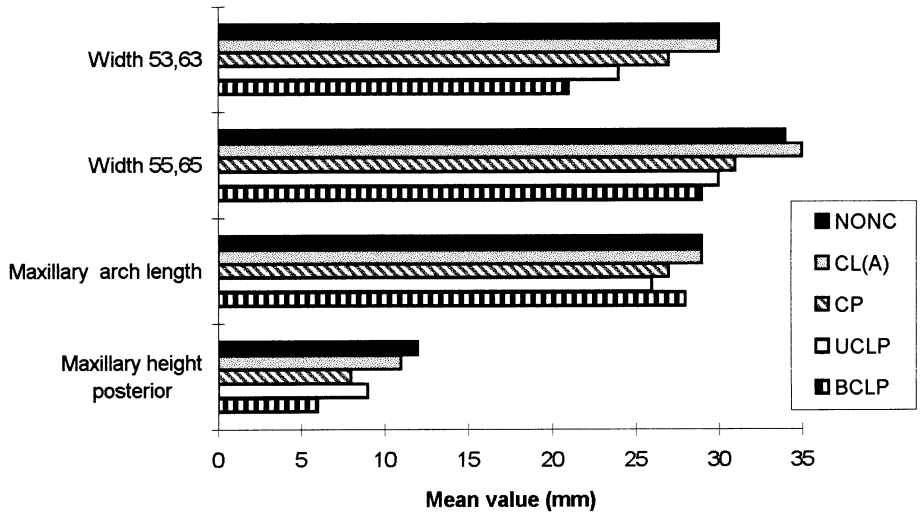

Fig. 1. Maxillary dental arch dimensions in non-cleft children (NONC) and children with different types of clefts at the age of 6 years. See Table 1 for other abbreviations.

in the corresponding comparisons: the width between the first deciduous molars between girls with and without the /l/-error ($P = 0.047$).

Isolated /r/-, /s/-, and /l/-misarticulations by sex

Boys with only /s/-errors had significantly narrower (widths, 53.63 and 54.64; $P = 0.010$; x2−x1 = 3.4 mm; and width, 55.65; $P = 0.000$; x2−x1 = 4.6 mm) and shorter ($P = 0.021$; x2−x1 = 2.0 mm) maxillary dental arches than boys with correct /r/-, /s/-, and /l/-production. Girls with only /r/-errors also had significantly narrower (width, 53.63; $P = 0.018$; x2−x1 = 2.1 mm; and width, 54.64; $P = 0.005$; x2−x1 = 2.2 mm), shorter ($P = 0.000$; x2−x1 = 1.6 mm), and posteriorly shallower ($P = 0.015$; x2−x1 = 1.4 mm) maxillary dental arches than girls with correct articulation of all the studied sounds. There were too few girls with only /s/- or only /l/-errors and too few boys with only /l/-errors to be tested statistically reliably.

Misarticulations of one or more studied sounds in different cleft subgroups

Table 3 shows statistically significant differences in mean values of the dental arch dimensions between children with and without /r/-, /s/-, or /l/-errors or their combinations by cleft type. Generally, patients with misarticulations had smaller dimensions than subjects without such errors, except for unilateral cleft lip and palate (UCLP) boys with /r/-disorders, who showed significantly longer maxillary dental arches than those

Table 2. Statistical comparisons of the mean values (d, mm) of the maxillary dental arch dimensions between subjects with /r/-, /s/-, or /l/-misarticulation including their combinations (*n*1) and subjects without them (*n*2), separately by sex for all cleft types

	Boys ($n = 154$)						Girls ($n = 109$)					
	/r/-sound ($n1 = 67$, $n2 = 87$)		/s/-sound ($n1 = 45$, $n2 = 109$)		/l/-sound ($n1 = 33$, $n2 = 121$)		/r/-sound ($n1 = 26$, $n2 = 83$)		/s/-sound ($n1 = 14$, $n2 = 95$)		/l/-sound ($n1 = 13$, $n2 = 96$)	
Dental arch dimensions	*P*	d	*P*	d	*P*	d	*P*	d	*P*	d	*P*	d
Width 53,63	0.000***	2.3	0.000***	2.9	0.004**	2.3	0.000***	4.2	0.005**	4.0	0.000***	6.5
Width 54,64	0.004**	2.0	0.000***	2.6	0.000***	2.5	0.000***	3.7	0.000***	3.8	0.000***	5.4
Width 55,65	0.016*	1.4	0.000***	2.6	0.002**	2.2	0.000***	2.3	0.000***	3.1	0.000***	3.3
Maxillary arch length	NS		0.023*	1.0	0.034*	1.0	0.000***	1.2	NS		NS	
Palatal height anterior	NS		NS		NS		0.000***	1.8	0.035*	1.4	0.005**	2.0
Palatal height posterior	NS		NS		NS		0.000***	2.1	0.008**	1.9	0.002**	2.2

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.
d = difference of the mean values (x2 − x1, mm) of the dental arch dimensions between subjects without (*n*2) and with (*n*1) misarticulations; NS = not significant.

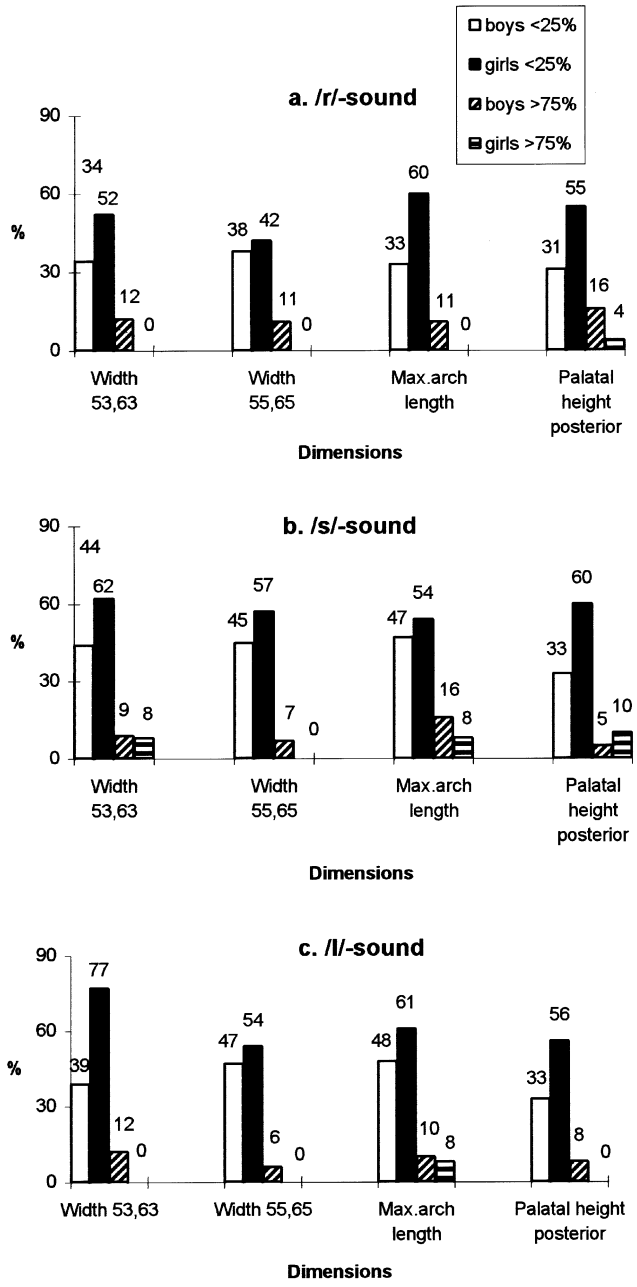

Fig. 2. Occurrence of /r/-errors (a), /s/-errors (b), and /l/-errors (c) in cleft-affected subjects ($n = 263$) in the smallest (<25%) quartile and biggest (>75%) quartile of maxillary dental arch dimensions by sex.

with correct /r/-production. /R/-, /s/-, and /l/-misarticulations in UCLP boys, as well as /r/-misarticulations in isolated cleft palate (CP) girls and BCLP boys, were associated with narrower or shorter maxillary dental arch.

To find out the possible effect of different etiology of clefting on misarticulations, subjects with CP and subjects with cleft lip with or without cleft palate (CL(P)) were studied separately. Because of the small number of CP subjects with misarticulations, only dental arch dimensions of girls and boys with /r/-errors could be tested statistically reliably, and the only significant results were found in CP girls (Table 3). In the CL(P) group the findings were the same as presented in Table 2 for the combined study population.

Table 3. Significant differences in mean values of dental arch dimensions (d) between subjects with and without /r/-, /s/-, or /l/-error or their combinations, by type of cleft and by sex

Sound	Cleft type†	Subjects	Dental arch dimension	*P*	d‡ (mm)
/r/	CP	Girls	Width 54,64	0.048*	0.9
/r/	CP	Girls	Mandibular arch length	0.033*	0.9
/r/	UCLP	Boys	Maxillary arch length	0.025*	−1.1
/r/	BCLP	Boys	Width 53,63	0.040*	4.9
/s/	UCLP	Boys	Width 55,65	0.012*	2.1
/l/	UCLP	Boys	Width 55,65	0.039*	2.3

† Abbreviations as in Table 1.
‡ As in Table 2.
* $P < 0.05$.

Discussion

Our retrospective clinical articulatory data can be considered to be very reliable because, as the treatment is centralized, we have information concerning each child's development since birth in the hospital records. The size and consistency of our material should be considered representative for examining the correlation between dental arch sizes and misarticulations. However, the distribution of the material into small subgroups caused difficulties in choosing the statistical analyses, and thus complicated the conclusions. Therefore, we assumed that the abnormalities in sizes of dental arches, rather than the different etiology of the clefting per se, affected the production of the dental sounds (18). The two sexes had to be examined separately since their dental arch dimensions differed significantly, and because boys more often misarticulated at least one of the studied sounds (52%) than girls (30%). Generally, Finnish non-cleft children are expected to be able to correctly produce /r/-, /s/-, and /l/-sounds by the age of 5 years, and thus the mean age of present subjects is adequate.

The present results showed that only the maxillary dental arch dimensions differed between patients with and without misarticulations. Generally, a narrow maxillary dental arch, especially anteriorly, was the most common finding among subjects with /r/-, /s/-, or /l/-misarticulations. Shorter maxillary dental arches were found among boys with /s/- or /l/-disorders and girls with /r/-errors, but shallower palates existed only in girls with the studied errors. On the whole, the smaller size of the maxillary dental arch per se seems to be associated with the occurrence of dental consonant misarticulations. These findings are in agreement with the results of earlier studies with cleft patients (12, 19) and non-cleft adults (20). Powers

(11) stated that subjects with /r/- or /l/-distortions keep the tongue placed posteriorly and inferiorly instead of raising it to the alveolar ridge, and Laine et al. (21) suggested that certain sounds may be produced too far posteriorly owing to a deficiency in maxillary anterior space. Wilcox et al. (22) stated that subjects with reduced maxillary dental arches may have insufficient space for the tongue to obstruct the airstream adequately in order to produce the /s/-sound correctly. On the other hand, Bishara et al. (13) found that subjects with isolated cleft palates with good or poor articulation did not differ systematically in their facial and dental relations. Interestingly, small maxillary dental arch dimensions seemed to be more related to the occurrence of misarticulations among girls than boys. However, highly adaptable speech mechanisms and widely ranging compensatory behavior can result in adequate articulation even in the presence of severe abnormalities of the orofacial structures. Therefore, the size of dental arches should be considered only a possible contributing hazard to clear speech production. For example, despite their smaller dental arches, girls had less serious problems with dental sound articulation than boys, which can be explained by their earlier speech development (23–26). Velopharyngeal incompetence, alveolar fistulas, and the presence or absence of incisors may have interfered with the articulation of some of the present subjects, and these topics will be studied later. The association between the occurrence of /r/-, /s/-, and /l/-misarticulations and the dental occlusion, dentofacial cephalometrics, and pharyngeal morphology of our subjects will also be examined.

References

1. Philips BJ, Harrison RJ. Articulation patterns of preschool cleft palate children. Cleft Palate J 1969;6:245–53.
2. McWilliams BJ, Musgrave RH. Diagnosis of speech problems in patients with cleft palate. Br J Disord Commun 1977;6:26–32.
3. Van Demark DR, Morris HL, VandeHaar C. Patterns of articulation abilities in speakers with cleft palate. Cleft Palate J 1979;16:230–9.
4. Laitinen JM, Haapanen M-L, Paaso M, Pulkkinen J, Heliövaara A, Ranta R. Occurrence of dental consonant misarticulations in different cleft types. Folia Phoniatr Logop 1998;50:92–100.
5. Sonninen A, Sonninen E. Logopedic-phoniatric observations on 8-year-old schoolchildren in the town of Jyväskylä. Nord Tidskr Logoped Foniat 1976;1:74–82.
6. Qvarnström MJ, Laine MT, Jaroma SM. Prevalence of articulatory disorders of different sounds in a group of Finnish first-graders. J Commun Disord 1991;24:381–92.
7. Ross BR, Johnston MC. Cleft lip and palate. Baltimore (MD): Williams & Wilkins; 1972. p. 219.
8. Friede H, Persson E-C, Lilja J, Elander A, Lohmander-Agerskov A, Söderpalm E. Maxillary dental arch and occlusion in patients with repaired clefts of the secondary palate. Scand J Plast Reconstr Hand Surg 1993;27:297–305.
9. Hellquist R, Ponten B, Skoog T. The influence of cleft length and palatoplasty on the dental arch and the deciduous occlusion in cases of clefts of the secondary palate. Scand J Plast Reconstr Surg 1978;12:45–54.
10. Nyström M, Ranta R. Effect of timing and method of closure of isolated cleft palate on development of dental arches from 3 to 6 years of age. Eur J Orthod 1994;16:377–83.
11. Powers MH. Functional disorders of articulation-symptomatology and etiology. In: Travis LE, editor. Handbook of speech pathology and audiology. New York: Appleton-Century-Crofts; 1971. p. 837–75.
12. Starr CD. Dental and occlusal hazards to normal speech production. In: Grapp WC, Rosenstein SW, Bzoch KR, editors. Cleft lip and palate: surgical, dental and speech aspects. Boston: Little, Brown and Company; 1971. p. 670–80.
13. Bishara SE, Van Demark DR, Henderson WG. Relation between speech production and oro-facial structures in individuals with isolated clefts of the palate. Cleft Palate J 1975; 12:452–60.
14. Laine T. Associations between articulatory disorders in speech and occlusal anomalies. Eur J Orthod 1987;9:144–50.
15. Heliövaara A, Rintala A, Ranta R. One-stage closure of isolated cleft palate with the Veau-Wardill-Kilner V to Y pushback procedure or the Cronin modification. Scand J Plast Reconstr Hand Surg 1993;27:49–54.
16. Moorrees CFA. Dentition of the growing child: a longitudinal study of dental development between 3 and 18 years of age. Cambridge (MA): Harvard University Press; 1959. p. 245.
17. Winer BJ. Statistical principles in experimental design. 2nd ed. New York: McGraw-Hill; 1971. p. 283–96.
18. Fogh-Andersen P. Epidemiology and etiology of clefts. Birth Defects 1971;7:50–3.
19. Okazaki K, Kato M, Onizuka T. Palate morphology in children with cleft palate with palatalized articulation. Ann Plast Surg 1991;26:156–63.
20. Oliver RG, Evans SP. Tongue size, oral cavity size and speech. Angle Orthod 1986;56:234–43.
21. Laine T, Jaroma M, Linnasalo A-L. Relationships between interincisal occlusion and articulatory components of speech. Folia Phoniatr 1987;39:78–86.
22. Wilcox KA, Stephens MI, Daniloff RG. Mandibular position during children's defective /s/ productions. J Commun Disord 1985;18:273–83.
23. Stevenson J, Richman N. The prevalence of language delay in a population of three-year-old children and its association with general retardation. Dev Med Child Neurol 1976;18:431–41.
24. Silva PA. The prevalence, stability and significance of developmental language delay in preschool children. Dev Med Child Neurol 1980;22:768–77.
25. Kirkpatrick E, Ward J. Prevalence of articulation errors in New South Wales primary school pupils. Aust J Hum Commun Disord 1984;12:55–62.
26. Luotonen M. Early speech development, articulation and reading ability up to the age of 9. Folia Phoniatr Logop 1995; 47:310–7.

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