One-stage closure of isolated cleft palate with the Veau–Wardill–Kilner V to Y pushback procedure or the Cronin modification

III. Comparison of lateral craniofacial morphology

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The craniofacial morphology of 116 consecutive patients with isolated cleft palate was studied by means of lateral cephalograms at 17 to 20 years of age. One-stage hard- and soft-palate closure had been carried out at the mean age of 1.8 years by using the Veau–Wardill–Kilner or the Cronin mucoperiosteal palatal V–Y pushback technique. In the Veau–Wardill–Kilner group the cranial base was longer, the cranial base angle was larger, and the mandible longer and its ramus higher but less backward rotated. The patients with originally the most extensive clefts showed the most marked deviations in craniofacial morphology at adult age.
□ *Cephalometry; cleft palate; surgery*

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The craniofacial morphology of children with isolated cleft palate has been reported to differ from that of noncleft children or children with other cleft types (1). The maxilla and mandible are usually well related to each other but retrusive in relation to the cranial base (1–4). Furthermore, maxillary depth, mandibular length, and posterior facial height are reduced (5, 6). The surgically and nonsurgically treated children have been demonstrated to show great similarity in this respect (3). On the other hand, controversy exists with regard to the type and timing of palatal surgery. Long-term studies with homogeneous samples are of importance.

This paper is part of a series evaluating the long-term effects of one-stage palatal closure with the Veau–Wardill–Kilner or the Cronin V to Y pushback procedures involving the same schedule. The purpose of this study was to examine the relationships between craniofacial measurements and the surgical method in patients with isolated cleft palate. In addition, the effects of sex, cleft extent at birth, familial disposition for clefts, associated minor anomalies, and additional palate operations were evaluated.

Materials and methods

The subjects comprised 116 consecutive Finnish patients with isolated cleft palate (ICP), born between 1968 and 1971. One-stage palatal closure was done at the Cleft Center, Department of Plastic Surgery, Helsinki University Central Hospital, using the Veau–Wardill–Kilner (VK) or the Cronin (C) mucoperiosteal V–Y pushback technique. The former was used between 1969 and 1971, and the latter since 1971. All the patients were operated on at the mean age of 1.8 years, mostly by residents in plastic surgery under training. In the Cronin cleft palate repair the V–Y pushback of the oral layer is done exactly as in the Veau–Wardill–Kilner, with two mucoperiosteal palatal flaps. In addition to this, the Cronin modification entails use of additional mucosal flaps from the floor of the nose to the nasal side of the soft palate. Brauer (7) and Cronin (8) have pointed out that in this manner the scar contracture of the healing raw area on the nasal surface could be avoided, and the mobility of the velum improved. The operative techniques have been described in more detail elsewhere (9).

The patients attended regular follow-up clinics where dental casts, cephalograms, and speech examinations were made. This study used the lateral cephalograms at the 17- to 20-year-old follow-up. During 1988 a total of 160 patients with isolated cleft palate were asked to come for long-term evaluation; 131 (82%) patients attended: 69 of 86 in the VK and 62 of 74 in the C group. In this study 15 patients (8 in the VK and 7 in the C group) who had specific syndromes, such as the Pierre Robin sequence or Down's syndrome, were excluded. The remaining 116 patients were grouped in accordance with surgical treatment with 1) the Veau–Wardill–Kilner or 2) the Cronin procedure. Further grouping was done on the basis of sex, cleft extent at birth, familial disposition for clefts, associated minor anomalies, and additional palate operations. The family history was considered positive if the patient had one or more first- or second-order relatives with a cleft of any type. The group with associated anomalies (n = 14) included children with van der Woude syndrome (n = 5), hypospadias (n = 1), inguinal hernia (n = 1), syndactylism (n = 1), and anomalies of the ear (n = 2), heart (n = 2), genitalia (n = 1), and cervical vertebrae (n = 1). The clefts were classified on the basis of hospital records and/or dental casts made before the primary operation. The primary clefts were defined as complete when the cleft reached the anterior half of the palate, partial when the cleft reached the posterior half of the palate, and soft when the cleft was of the soft palate only. The comparability of the patients is given in Table 1.

The mean (SD) age at the time of the primary operation was 1.8 (0.31) years in both the VK (SD = 0.18) and C (SD = 0.41) group (NS). The mean (SD) age of all patients at the long-term evaluation was 18.8 (1.15) years: 19.7 (0.72) in the VK group and 17.8 (0.59) in the C group ($p < 0.001$).

Of the 116 children 104 had received orthodontic treatment. None of them had undergone orthognathic surgery. Height, weight, and the size of dental arches of the patients are reported in a separate paper (10).

Table 1. Comparability of the group

	Veau–Wardill–Kilner pushback operation			Cronin modification			
	Boys	Girls	Total	Boys	Girls	Total	Total
No. of operations							
Primary only	14	30	44	18	26	44	88
Primary and secondary	9	8	17	7	4	11	28
Morphologic classification							
Complete	2	8	10	5	10	15	25
Partial	16	23	39	9	14	23	62
Cleft of soft palate only	5	7	12	11	6	17	29
Familial disposition							
No	16	26	42	22	23	45	87
Yes	7	12	19	3	7	10	29
Associated anomalies							
No	20	33	53	21	28	49	102
Yes	3	5	8	4	2	6	14
Total	23	38	61	25	30	55	116

Cephalometric measurements

Lateral cephalometric roentgenograms, taken with the patient's head positioned in accordance with the Frankfort horizontal plane with molar teeth occluded, were traced twice by the same person. The tracings were digitized by means of a computer-connected digitizer. The computer was programed to calculate the mean of the two digitizations, which were to be at an accuracy of 1 mm. The landmarks that could not be properly identified were excluded. In the analysis of soft-tissue morphology eight patients were excluded because their lips were not in contact. All measurements were corrected for cephalometric enlargement. The landmarks used and their definitions are given in Fig. 1. Distances are reported in millimeters and angles in degrees. The same dimensions were used in both multivariate analyses. For clarity, the dimensions were divided into four groups of measurements: cranial base, upper face, lower face, and vertical dimensions.

Statistical methods

Multivariate discriminant function analysis and multiple linear regression analysis were used in the statistical analysis. Test statistics with p values equal to or less than 0.05 were considered statistically significant.

A forward-stepping multivariate discriminant function analysis (BMDP7M) (11) was used to determine the degree to which the two groups operated on by different methods could be maximally distinguished. Boys and girls were analyzed together. Discriminant function analysis finds the combination of variables which best predicts the category or group to which a case belongs.

Multiple linear regression analysis (BMDP1R) (12) estimates a least-squares equation between a dependent variable and one or more independent variables. Cephalometric dimensions were used as the dependent variables, and operation method, sex, cleft extent at birth, familial disposition for clefts, associated minor anomalies, and additional palate operations were chosen for the independent variables. The independent variable cleft size was represented in the model by suitable dummy variables, and one of the three categories was always ignored. By using multivariate regression it is possible 1) to find out how much of the total variance is explained by the independent variables, 2) to separate and quantify the influence of the independent variables on the dependent variable, and 3) to test whether the effect is statistically significant.

Results

The multivariate discriminant function analysis, with operation method as a grouping variable, gave no discriminating variables for soft-tissue dimensions at a tolerance of 0.01 and F-to-enter 4.00. The F-to-enter for a variable corresponds to the F statistics computed from one-way analysis of variance (ANOVA) of that variable for the groups used in the analysis. The discriminating function for skeletal variables classified 56.3% of the material correctly, the best discriminating factor being mandibular ramus height, Ar-Tgo′. This dimension was larger in the VK group.

The results of the multiple linear regression with regard to the method of operation, sex, and extent of cleft are shown in Table 2. For the measure cleft extent only the smallest p value is given. The R^2 values for the regression model for the soft-tissue variables indicate that 1.5–52% of the independent variables' variance was explained. In the case of skeletal dimensions the R^2 values explained 3–45% of the variance. There was a tendency towards smaller R^2 values with angular dimensions.

The most important independent variable in the multiple linear regression was sex. All linear distances and angle S-N-Pog were significantly larger for males. The significant findings with regard to the surgical method were related to cranial base, posterior face height, and size and position of the mandible. In the VK group the cranial base angle N-S-Ba, the distance N-Ba, and the posterior face height S-Tgo′ were greater. The mandible was longer and higher (Me-Tgo′, Ar-Tgo′, and Gn-Cd), but the incli-

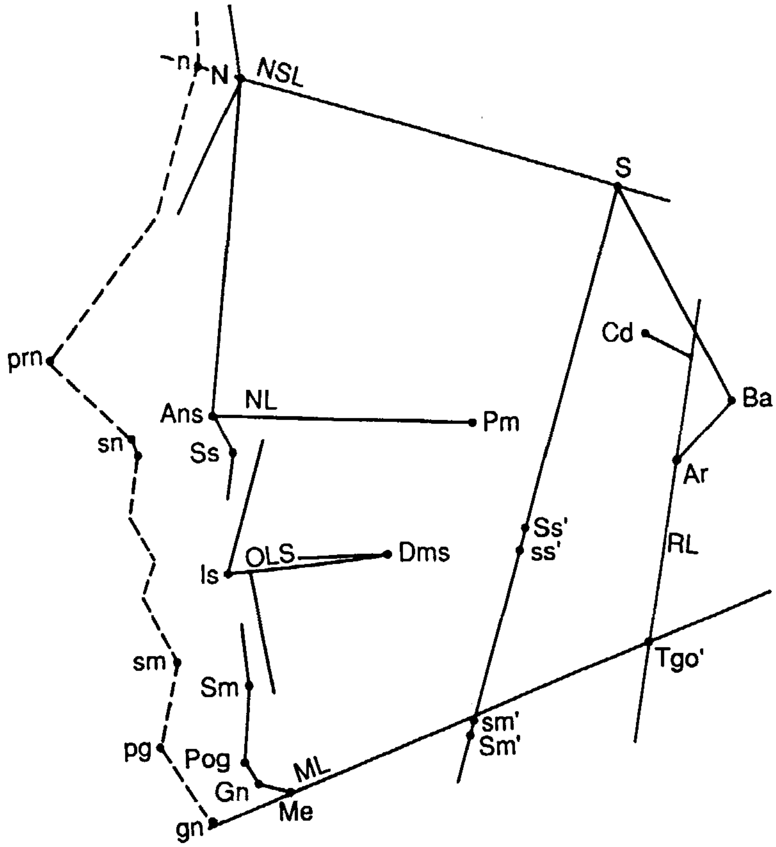

Fig. 1. The reference points and reference lines used in the cephalometric analysis. Abbreviated and full names and definitions: Ans (anterior nasal spine) = tip of anterior nasal spine; Ar (articulare) = intersection between the external contour of the cranial base and the dorsal contour of mandible; Ba (basion) = most inferior point on the clivus of the occipital bone; Cd (condylion); most posterior and superior point on the condylar head; Dms = distobuccal cusp of the upper first permanent molar; Gn (gnathion) = most anterior and inferior point of bony chin; gn (soft-tissue gnathion) = lowest point of soft-tissue chin; Is (incisive superior) = incisal edge of average maxillary central incisor; N (nasion) = most anterior point on the nasofrontal suture; n (soft-tissue nasion) = intersection between NSL and soft profile contour; Me (menton) = most inferior point on mandibular symphysis; pg (soft-tissue pogonion) = most anterior point of soft-tissue chin; Pm (pterygomaxillare) = intersection between the nasal floor and posterior contour of maxilla; Pog (pogonion): most prominent point of bony chin; prn (pronasale) = most prominent point of apex nasi; S (sella): centre of sella turcica; Sm (supramentale) = deepest point on the anterior contour of the mandibular alveolar arch; sm (soft-tissue supramentale) = deepest point of the soft-tissue contour of the lower jaw; Sm' (projection of point Sm) = projection of point Sm on a vertical line perpendicular to NSL; sm' (projection of point sm) = projection of point sm on a vertical line perpendicular to NSL; sn (subnasale) = point at which columnella merges with upper lip; Ss (subspinale) = deepest point on the anterior contour of the maxillary alveolar arch; ss (soft-tissue subspinale) = deepest point of the upper lip; Ss' (projection point of Ss) = projection of point Ss on a vertical line perpendicular to NSL; ss' (projection point of ss) = projection of point ss on a vertical line perpendicular to NSL; Tgo' (gonion tangent point) = point of intersection between lines ML and RL; ML (mandibular line) = tangent to the lower border of mandible through Me; NL (nasal line) = line through points Ans and Pm; NSL (nasion–sella line) = line through points N and S; OLS (occlusal line superior) = line through points Is and Dms; and RL (ramus line) = tangent to the mandibular ramus through Ar.

nations of the mandibular plane (NSL/ML, NL/ML) and the gonial angle (RL/ML) were smaller.

Cleft extent had a significant effect on the distances N-S and Ss-Ss' and the angles S-N-Ss, S-n-ss, S-n-sm, and NSL/NL. Except for the anterior cranial base length N-S, these values were smallest in the group with total clefts. The patients who had relatives with clefts showed a greater vertical n-sn distance. With regard to the other independent variables, associated minor anomalies, and additional palate operations there were no significant findings.

Discussion

The most important findings of this study were related to sex, surgical method, and cleft extent at birth. However, caution is needed when discussing the practical importance of the results. Multivariate discriminant function analysis was used to determine the degree to which the two surgical methods can be maximally distinguished. The discriminant function determined for the skeletal variables classified 56.3% of the material correctly—that is, assigned them to the surgical groups to which they actually belong.

In the multiple regression analysis the R^2 values for the regression model indicated that 1.5–52% of the independent variables' variance was explained. There was a tendency for smaller R^2 values with angular measurements. The values are low but comparable to those reported earlier (13). By the multivariate regression method it is possible to separate and quantify the effect of each of the independent variables on the dependent variable, and in this manner the influence of surgery and sex can be isolated. However, it is not to be assumed that all observed variance is due to one factor, such as surgery. There may be differences in individual growth patterns and functions of respiration, deglutition, and speech, which may alter dentofacial growth. The small sample size must also be taken into consideration and mere coincidence kept in mind in interpreting these results.

The Cronin modification of the pushback may result in improved function of the velum (7, 8), but it is technically more difficult to do and results in larger denuded bone surfaces than does the Veau–Wardill–Kilner. The former method could thus have been expected to cause more growth disturbance. With regard to the surgical method, the significant findings of this study were related to the cranial base and the size and position of the mandible. In the VK group the cranial base angle (N-S-Ba), cranial base length (N-Ba), and posterior facial height (S-Tgo') were greater. The mandible was longer and its ramus higher (Me-Tgo', Ar-Tgo', and Gn-Cd) but less rotated backwards (NSL/ML, NL/ML, and RL/ML). The differences in mandibular size may be partly due to age distribution. The patients in the VK group were significantly older than those in the C group, and it is possible that postpubertal growth had occurred. It is also true that there were more girls in the C group. On the other hand, the differences in cranial base angle, posterior face height, and mandibular inclination might reflect differences in modes of respiration between the groups. Maxillary growth deficits constrict the nasal floor, reduce airway size, and increase airway resistance (14), which can lead to mouth-breathing.

There were no significant findings with regard to the number of additional palate operations. This is in contrast with the conclusion that multiple surgical procedures to the hard palate cause severe disturbances in maxillary growth (4). On the other hand, Semb & Shaw (15) have studied facial growth of 52 subjects with unilateral cleft lip and palate after superiorly based pharyngeal flaps; 5 years postoperatively they failed to identify any important differences in facial growth. In dental cast analysis (10) the patients of the present study who had been reoperated on most often showed shortest maxillary and mandibular dental arch widths between the first permanent molars.

The influence of sex in the multiple linear regression analysis was consistently in the same direction. All the linear measurements and the angle S-N-Pog had significantly greater values for males. Corresponding sex

Table 2. The results of the multiple linear regression analysis (method, Veau–Wardill–Kilner Cronin) (for definition of abbreviations, see Fig. 1 legend)

		Method	Sex*	Cleft extent†
Cranial base				
N-S-Ba				
$\bar{x}$ = 129.42 n = 115 SD = 5.66	Coeff	−2.16	1.44	−1.38 (p)
R^2 = 0.10	p	0.05	0.20	0.29
N-S				
$\bar{x}$ = 65.81 n = 116 SD = 3.51	Coeff	−0.54	−4.78	1.53 (c)
R^2 = 0.45	p	0.30	0.00	0.05
S-Ba				
$\bar{x}$ = 41.73 n = 115 SD = 2.96	Coeff	−0.45	−2.41	0.87 (p)
R^2 = 0.22	p	0.39	0.00	0.21
N-Ba				
$\bar{x}$ = 97.67 n = 115 SD = 4.79	Coeff	−1.65	−5.97	−1.89 (s)
R^2 = 0.42	p	0.03	0.00	0.09
Upper face				
N-Ans				
$\bar{x}$ = 48.28 n = 115 SD = 2.84	Coeff	−0.33	−3.04	−0.36 (p)
R^2 = 0.29	p	0.49	0.00	0.54
S-Pm				
$\bar{x}$ = 43.96 n = 113 SD = 3.77	Coeff	0.33	−4.02	0.82 (p)
R^2 = 0.34	p	0.60	0.00	0.32
Ans-Pm				
$\bar{x}$ = 45.81 n = 112 SD = 3.40	Coeff	−0.11	−3.44	0.44 (p)
R^2 = 0.28	p	0.85	0.00	0.54
S-N-Ss				
$\bar{x}$ = 78.21 n = 114 SD = 4.32	Coeff	−0.83	−0.22	−3.02 (c)
R^2 = 0.09	p	0.32	0.80	0.02
NSL/NL				
$\bar{x}$ = 8.71 n = 112 SD = 3.73	Coeff	−0.88	1.22	2.80 (s)
R^2 = 0.15	p	0.21	0.09	0.00
OLS/NL				
$\bar{x}$ = 8.59 n = 108 SD = 4.51	Coeff	1.48	0.16	−2.46 (s)
R^2 = 0.07	p	0.11	0.86	0.07
Lower face				
Gn-Cd				
$\bar{x}$ = 108.84 n = 112 SD = 7.11	Coeff	−3.25	−8.29	1.80 (p)
R^2 = 0.45	p	0.00	0.00	0.20
Me-Tgo′				
$\bar{x}$ = 64.51 n = 116 SD = 5.06	Coeff	−1.67	−5.47	−0.86 (s)
R^2 = 0.32	p	0.05	0.00	0.50
Ar-Tgo′				
$\bar{x}$ = 44.04 n = 116 SD = 5.16	Coeff	−2.79	−4.29	−0.39 (p)
R^2 = 0.22	p	0.00	0.00	0.72
S-N-Sm				
$\bar{x}$ = 77.56 n = 116 SD = 4.62	Coeff	−0.91	−1.13	−1.72 (p)
R^2 = 0.07	p	0.31	0.22	0.20
S-N-Pog				
$\bar{x}$ = 79.52 n = 116 SD = 4.69	Coeff	−1.04	−1.86	−1.00 (c)
R^2 = 0.08	p	0.25	0.05	0.47
Ss-N-Sm				
$\bar{x}$ = 2.46 n = 114 SD = 1.89	Coeff	−0.59	−0.03	0.43 (c)
R^2 = 0.03	p	0.12	0.94	0.39
NSL/ML				
$\bar{x}$ = 33.27 n = 116 SD = 6.64	Coeff	2.64	1.19	−0.82 (c)
R^2 = 0.05	p	0.04	0.38	0.68
NL/ML				
$\bar{x}$ = 24.40 n = 112 SD = 6.91	Coeff	3.25	−0.54	1.02 (p)
R^2 = 0.09	p	0.02	0.69	0.57

Table 2. (*Continued*)

		Method	Sex*	Cleft extent†
ML/RL				
$\bar{x} = 126.44$ $n = 116$ SD = 7.64	Coeff	1.60	−1.43	−1.42 (c)
$R^2 = 0.05$	*p*	0.29	0.35	0.47
Vertical				
N-Me				
$\bar{x} = 109.48$ $n = 116$ SD = 7.04	Coeff	0.24	−7.83	−0.91 (s)
$R^2 = 0.32$	*p*	0.83	0.00	0.61
S-Tgo′				
$\bar{x} = 72.51$ $n = 116$ SD = 5.65	Coeff	−1.85	−6.15	−1.05 (s)
$R^2 = 0.30$	*p*	0.05	0.00	0.47
Soft-tissue dimensions				
Cranial base				
n-S				
$\bar{x} = 72.41$ $n = 107$ SD = 4.34	Coeff	−0.82	−6.34	0.82 (c)
$R^2 = 0.52$	*p*	0.18	0.00	0.31
Upper face				
Ss-Ss′				
$\bar{x} = 54.81$ $n = 106$ SD = 4.76	Coeff	−0.94	−3.90	2.42 (c)
$R^2 = 0.25$	*p*	0.28	0.00	0.04
ss-ss′				
$\bar{x} = 68.87$ $n = 108$ SD = 5.83	Coeff	−0.88	−6.30	−1.56 (c)
$R^2 = 0.36$	*p*	0.36	0.00	0.28
S-n-ss				
$\bar{x} = 86.72$ $n = 107$ SD = 4.74	Coeff	−0.06	−0.03	−3.16 (c)
$R^2 = 0.08$	*p*	0.95	0.97	0.01
Lower face				
Sm-Sm′				
$\bar{x} = 46.72$ $n = 108$ SD = 7.87	Coeff	−1.90	−5.50	1.64 (p)
$R^2 = 0.19$	*p*	0.18	0.00	0.33
sm-sm′				
$\bar{x} = 57.56$ $n = 108$ SD = 7.59	Coeff	−1.53	−6.33	2.97 (p)
$R^2 = 0.24$	*p*	0.26	0.00	0.10
S-n-sm				
$\bar{x} = 80.42$ $n = 107$ SD = 4.75	Coeff	−0.48	−0.38	−2.79 (c)
$R^2 = 0.08$	*p*	0.61	0.70	0.02
S-n-pg				
$\bar{x} = 81.97$ $n = 107$ SD = 4.67	Coeff	−0.72	−0.84	1.01 (p)
$R^2 = 0.07$	*p*	0.44	0.39	0.37
ss-n-sm				
$\bar{x} = 6.33$ $n = 107$ SD = 2.32	Coeff	0.36	0.28	0.49 (s)
$R^2 = 0.04$	*p*	0.43	0.56	0.38
Vertical				
n-gn				
$\bar{x} = 113.96$ $n = 107$ SD = 7.64	Coeff	0.72	−8.37	−1.03 (s)
$R^2 = 0.32$	*p*	0.57	0.00	0.59
n-sn				
$\bar{x} = 53.48$ $n = 107$ SD = 3.43	Coeff	0.11	−3.60	0.94 (c)
$R^2 = 0.27$	*p*	0.85	0.00	0.31
sn-gn				
$\bar{x} = 62.46$ $n = 108$ Sd = 5.98	Coeff	0.87	−4.66	0.63 (p)
$R^2 = 0.21$	*p*	0.40	0.00	0.61
Convexity				
n-sn-pg				
$\bar{x} = 164.24$ $n = 107$ SD = 6.32	Coeff	−1.29	−1.30	1.28 (c)
$R^2 = 0.04$	*p*	0.32	0.33	0.45
n-prn-pg				
$\bar{x} = 133.54$ $n = 107$ SD = 5.65	Coeff	−0.41	0.22	−0.74 (s)
$R^2 = 0.02$	*p*	0.72	0.85	0.60

* Sex = male to female ratio.
† c = Complete; p = partial, s = soft.

differences in cleft palate children have also been previously demonstrated (13, 16, 17).

The effect of cleft morphology at birth was remarkable for the distances S-N and Ss-Ss′ and for the angles S-N-Ss, S-n-ss, S-n-sm, and NSL/NL. Except for anterior cranial base length (S-N) these values were smaller in the group with complete clefts. This may reflect a smaller and more retruded maxilla in this group. When studying 55 operated children with ICP from 10 to 11 years of age, Jonsson & Thilander (18) observed that there was a tendency for the maxilla to be more posteriorly located in the group with more extensive clefts. Smahel (19) studied 90 operated adult men with ICP and noted that soft-palate clefts were associated with less retrusion of the maxilla. Smahel further observed that in complete and incomplete clefts of the palate, maxillary retrusion was masked by soft tissues (increased thickness of upper lip), whereas this did not occur in clefts of the soft palate only. In the present study, however, the soft-tissue profile showed most marked deviations in the group with complete clefts.

A shorter maxillary length of wider clefts has previously been demonstrated (3, 18). In the present study the distance Ans-Pm was not affected by the cleft type, whereas the distance Ss-Ss′ was significantly shorter in the complete cleft group. Viteporn et al. (20) studied 52 Danish cleft palate patients from 5 to 21 years old and report a smaller maxillary dentoalveolar base length in patients with most extensive clefts. There were no significant findings in the mandible with regard to cleft extent. This is in accordance with Dahl (3), who studied 57 adult men with ICP and found that with regard to mandibular size, shape, and position the two subgroups, divided by extent of cleft, exhibited great similarity. Smahel (19) and Viteporn et al. (20) reached different conclusions: subjects with soft-palate clefts have the shortest mandibular lengths (19), in contrast to an observation in which the shortest mandibular lengths occur with total clefts (20).

Other previous studies dealing with craniofacial morphology of cleft-palate patients and the type of surgery have found it difficult to prove that the type of palatal surgery affects facial growth (13, 18, 21–24). Ross (25) has suggested that the surgeon has a greater effect on growth than does the technique being used. Differences in material and methods hamper comparison of these studies. Very few have comparable groups of patients with regard to type and timing of surgery, surgeon, cleft morphology, age, sex, race, associated anomalies, and orthodontic treatment. Moreover, the craniofacial measurements and statistical analysis vary. Furthermore, in addition to craniofacial morphology, the long-term results of cleft palate surgery should be judged by several other variables, like alveolar-dental dimensions and speech.

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