Craniofacial morphology in young adults with the Pierre Robin sequence and isolated cleft palate

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Laitinen SH, Heliövaara A, Ranta RE. Craniofacial morphology in young adults with the Pierre Robin sequence and isolated cleft palate. Acta Odontol Scand 1997;55:223–228. Oslo. ISSN 0001-6357.

The craniofacial morphology of 30 young adults with the Pierre Robin sequence, aged 17.0–27.1 years (mean, 20.8), was analyzed and compared with the craniofacial morphology of 116 young adults with isolated cleft palate, aged 16.9–20.6 years (mean, 18.8). All patients had been examined and operated on at the Cleft Center, Department of Plastic Surgery, Helsinki University Central Hospital. The skeletal dimensions of patients with Pierre Robin sequence differed from those of patients with isolated cleft palate by the shorter posterior cranial base, maxilla, and mandibular ramus. The mandible was also more retruded and more posteriorly rotated, and the soft tissue profile more convex in Pierre Robin sequence patients. In the pharyngeal area, the lower sagittal depth of the pharynx was significantly shorter and the hyoid bone position more inferior in those with Pierre Robin sequence than in those with isolated cleft palate. □ *Cephalometry; cleft palate; Pierre Robin sequence*

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The Pierre Robin sequence (PRS) is characterized by three defects: micrognathia, cleft palate, and glossoptosis. This sequence can occur alone or in association with other developmental defects or as part of a syndrome (1, 2). Glossoptosis is responsible for respiratory failure, which is later defined as respiratory distress (3, 4). Reports of the size of the tongue vary (1, 5), as do reports of the mechanisms of airway obstruction (4, 6, 7). The cause of the apnea is heterogeneous, with both neuromuscular maturation and volume and size of tissues being important factors maintaining airway patency (3, 4, 8). The death rate increases with the severity of symptoms, the associated anomalies, and the prematurity (9). The width and form of the cleft does not necessarily correlate with the degree of neonatal respiratory problems, and even a submucous cleft can be associated with severe respiratory symptoms as well (10).

At birth the mandible of the PRS infant is small and symmetrically receded (11). When compared with normal control infants, PRS infants have been reported to have a short mandible, a narrow airway, and a posterior and inferior position of the hyoid bone (5). The presumed mandibular catch-up growth later on partially improves the jaw relationship and profile but not always enough to reach normal craniofacial dimensions (12–14).

Previous studies (6, 14–16) have suggested that the craniofacial morphology of PRS children resembles that of isolated cleft palate patients (ICP) except for the mandible. The aim of this study was to compare the craniofacial morphology of young adults with PRS and ICP. The PRS group was also studied with regard to gender, operation, and extent of the cleft.

Materials and methods

This study is one in a series of studies examining craniofacial characteristics in patients with PRS. Of 49 young adults asked to participate in the cephalometric examination, 30 (61%) attended. This series comprised 14 males and 16 females with PRS, all born in 1965–75. Their ages were 17.0–27.1 years (mean, 20.8). The diagnostic criteria for PRS were micrognathia, cleft palate, and various degrees of respiratory difficulties caused by glossoptosis in early infancy. All were examined by a pediatrician. The control group consisted of 116 ICP patients (48 males and 68 females), born in 1968–71, aged 16.9–20.6 years (mean, 18.8). The control group has been described in more detail elsewhere (17, 18).

In both the PRS and ICP groups patients with distinct syndromes (like the Stickler syndrome) were excluded, but 6 patients in the PRS group and 14 in the ICP group (17, 18) had associated anomalies. In the PRS patients the associated anomalies included hypertelorism (n = 1), epicanthal folds (n = 1), anomaly of the inner ear (n = 1), flaccid ligaments (n = 1), intra-abdominal anomaly (n = 1), and genital anomaly (n = 1). The ICP group included patients with van der Woude's syndrome (n = 5), hypospadias (n = 1), inguinal hernia (n = 1), syndactyly (n = 1), and anomalies of the ear (n = 2), heart (n = 2), genitals (n = 1), and

Table 1. Comparability of 30 Pierre Robin sequence (PRS) and 116 isolated cleft palate (ICP) patients on the basis of surgical methods, cleft extent, and number of associated anomalies

	PRS				ICP			
	Males	Females	Total	(%)	Males	Females	Total	(%)
No. of operations								
Veau–Wardill–Kilner								
Alone	1	1	2	(7)	14	30	44	(38)
With secondary	3	3	6	(20)	9	8	17	(15)
Cronin modification								
Alone	5	7	12	(40)	18	26	44	(38)
With secondary	5	5	10	(33)	7	4	11	(9)
Morphologic classification								
Complete	3	8	11	(37)	7	18	25	(22)
Partial	10	8	18	(60)	25	37	62	(53)
Cleft of soft palate	1	—	1	(3)	16	13	29	(25)
Associated anomalies								
No	12	12	24	(80)	41	61	102	(88)
Yes	2	4	6	(20)	7	7	14	(12)
Total	14	16	30	(100)	48	68	116	(100)

cervical vertebra ($n = 1$). All the patients had been treated at the Cleft Center, Department of Plastic Surgery, Helsinki University Central Hospital. One-stage hard- and soft-palate closure had been performed with the Veau–Wardill–Kilner or the Cronin mucoperiosteal palatal V–Y push-back technique. Sixteen (53%) of the PRS patients and 28 (24%) of the ICP patients had had secondary palatal operations, mainly pharyngeal flaps and repair of fistulas (Table 1). All PRS patients and 90% of the ICP patients had received orthodontic treatment including guided extractions and fixed appliances. None of the patients had had orthognathic surgery. The comparability of the groups can be seen in Table 1.

Lateral cephalometric radiographs were taken with a cephalostat in the Frankfort horizontal plane with molar teeth occluded. For the landmarks used and their definitions, see Fig. 1. The landmarks of the cephalograms were traced twice by a computer-connected digitizer. The computer was programed to calculate the mean of the two digitalizations, which were to be at an accuracy of 1 mm. Any landmark that could not be properly identified was left unidentified (dummy). The magnifications of the radiographs were corrected for the cephalometric enlargement. The PRS patients were examined by the first author (S. Laitinen), and the control group of ICP patients was handled by the second author (A. Heliövaara). The inter-examiner error was measured with a paired t test of 20 cephalograms. No significant differences were observed (t values were between 0.003 and 1.37). The digitalization between the authors diverged most in the S-n-ss ($P = 0.18$), S-n-pg ($P = 0.24$), and n-prn-pg ($P = 0.19$) variables and least in N-S, NSL/ML, ML/RL, N-ME, S-TGO′, GN-CD, S-n-sm, ss-n-sm, HY-HY′, HY-GN ($P = 0.96$–0.99) variables. One dummy point of the ANS landmark was counted.

Student's t test was used in the statistical analysis of the differences between variables in the PRS groups, on the basis of sex, cleft extent, operation methods, and comparison of the PRS group with the ICP group. The biomedical data package (BMDP, Statistical Software, Inc, 1990) was used for the analysis.

Results

Cephalometric comparison of the PRS and ICP groups can be seen in Table 2, with combined gender. Significant skeletal differences were observed in the length of the posterior cranial base (S-BA), maxilla (ANS-PM), and mandibular ramus (AR-TGO′). They were shorter in the PRS group. Moreover, in the PRS group the mandible was more retruded (S-N-SM, S-N-POG) and more backwards-rotated (NSL/ML).

The soft-tissue profile was more convex (ss-n-sm, n-sn-pg, n-prn-pg) and the lower anterior face height (sn-gn) was longer in the PRS group.The hyoid was located lower (HY-HY′), and the lower sagittal depth of the pharynx was shorter (PAS) in the PRS than in the ICP group.

The comparison on the basis of gender in the PRS group showed that the linear measurements in males were greater than in females. Comparison of the angular measurements showed no differences, although the maxillary and mandibular retrusions (S-N-SS, S-N-SM, S-N-POG, S-n-ss, S-n-sm, S-n-pog) in males were slightly but not significantly more severe than in females. The backward rotation of the mandible (NSL/ML, NL/ML, ML/RL) was more severe in males than in females but at a low level of significance ($P < 0.05$).

The extent or the cleft or the method of palatal closure (Cronin or Veau–Wardill–Kilner) made no

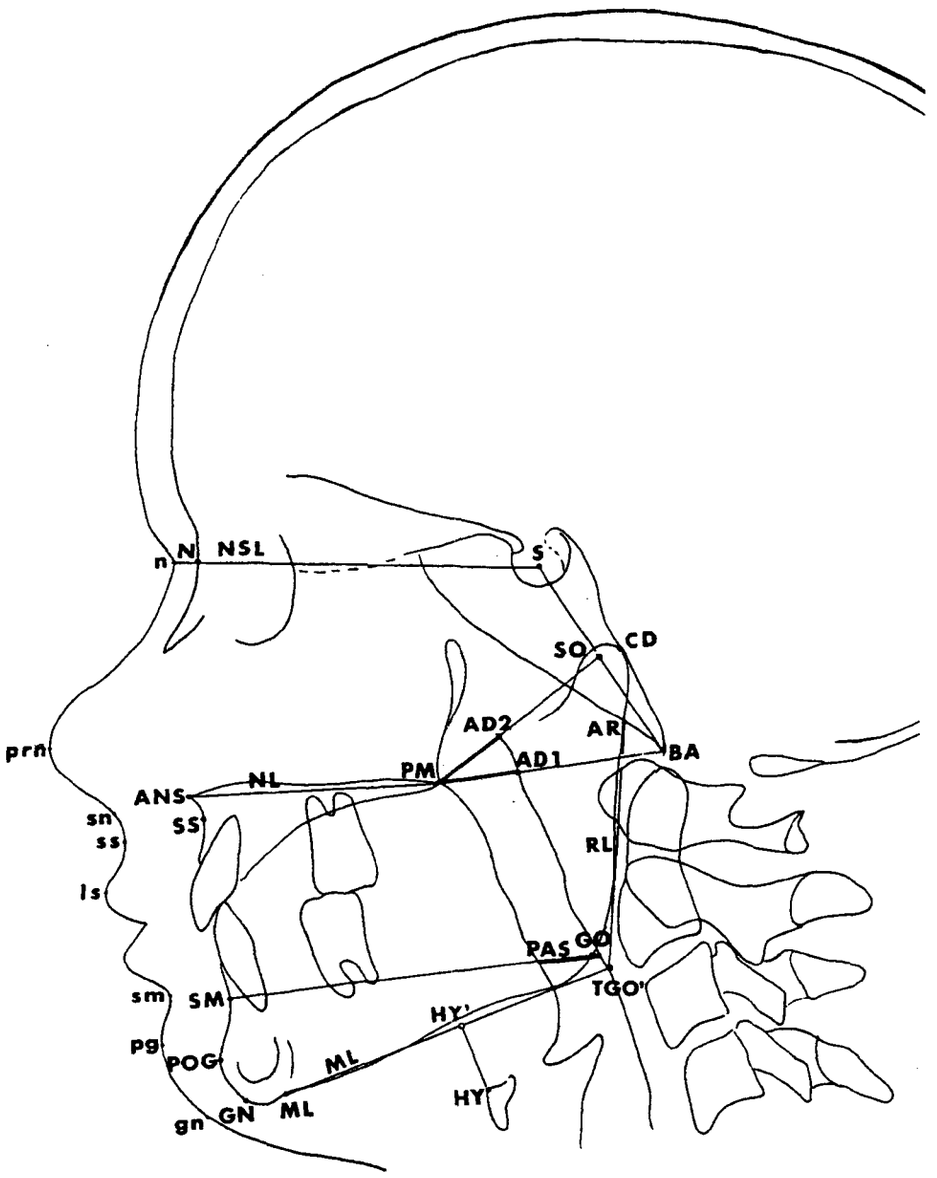

Fig. 1. Reference points and reference lines for cephalometric analysis. Abbreviated and full names and definitions: *Points*: AD1 = intersection of line PM-BA and posterior nasopharyngeal wall; AD2 = intersection of line PM-SO and posterior nasopharyngeal wall; ANS (anterior nasal spine) = tip of anterior nasal spine; AR (articulare) = intersection between external contour of cranial base and dorsal contour of mandible; BA (basion) = most inferior point on clivus of occipital bone; CD (condylion) = most posterior and superior point on condylar head; GN (gnathion) = most anterior and inferior point of bony chin; gn (soft-tissue gnathion) = lowest point of soft-tissue chin; GO (gonion) = intersection between external contour of mandible and bisector of angle between lines RL and ML; HY (hyoid) = most anterior and superior point of hyoid bone; HY' (projection point of HY) = perpendicular distance of point HY on mandibular plane; ME (menton) = most inferior point on mandibular symphysis; N (nasion) = most anterior point of nasofrontal suture; n (soft-tissue nasion) = intersection between NSL and soft-tissue profile contour; ls (labrale superius) = margin of the vermilion of the upper lip; PAS (posterior air space) = sagittal depth of pharynx on line intersecting points SM and GO; pg (soft-tissue pogonion) = most anterior point of soft-tissue chin; PM (pterygo-maxillare) = intersection of nasal floor and posterior contour of maxilla; POG (pogonion) = most prominent point of bony chin; prn (soft-tissue pronasale) = most prominent point of apex nasi; S (sella) = center of sella turcica; SM (supramentale) = deepest point on anterior contour of mandibular alveolar arch; sm (soft-tissue supramentale) = deepest point of soft-tissue contour of lower jaw; sn (subnasale) = point at which columnella merges with upper lip; SO = midpoint of distance from points S to BA; SS (subspinale) = deepest point on anterior contour of maxillary alveolar arch; ss (soft-tissue subspinale) = deepest point of upper lip; TGO' (gonion tangent point) = point of intersection between lines ML and RL. *Lines*: ML (mandibular line) = tangent to 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; RL (ramus line) = tangent to mandibular ramus through AR.

Table 2. Cephalometric measurements (mean and standard deviation (*s*)) in 30 Pierre Robin sequence (PRS) and 116 isolated cleft palate (ICP) patients

	PRS			ICP				
Cephalometric variable	Mean	*s*	*n*	Mean	*s*	*n*	*t*	*P*
Cranial base								
N-S-BA°	128.5	(6.1)	30	129.4	(5.7)	115	−0.71	
N-S(mm)	66.3	(4.4)	30	65.8	(3.5)	116	0.56	
S-BA(mm)	40.1	(3.9)	30	41.7	(3.0)	115	−2.16	*
N-BA(mm)	96.4	(6.4)	30	97.7	(4.8)	115	−1.01	
Upper and lower face								
S-N-SS°	78.0	(4.0)	30	78.2	(4.3)	114	−0.24	
S-N-SM°	74.6	(4.3)	30	77.6	(4.6)	116	−3.34	**
S-N-POG°	76.7	(4.9)	30	79.5	(4.7)	116	−2.88	**
SS-N-SM°	3.9	(2.3)	30	2.5	(1.9)	114	3.20	**
NSL/ML°	37.0	(8.8)	30	33.3	(6.6)	116	2.19	*
NL/ML°	26.5	(8.6)	30	24.4	(6.9)	112	1.23	
ML/RL°	126.2	(8.9)	30	126.4	(7.6)	116	−0.15	
N-ANS(mm)	48.6	(4.4)	30	48.3	(2.8)	115	0.39	
N-ME(mm)	111.7	(8.8)	30	109.5	(7.0)	116	1.27	
S-TGO'(mm)	71.0	(5.6)	30	72.5	(5.7)	116	−1.30	
S-PM(mm)	43.8	(4.4)	30	43.9	(3.8)	113	−0.13	
ANS-PM(mm)	44.4	(3.4)	30	45.8	(3.4)	112	−2.07	*
GN-CD(mm)	107.5	(7.1)	30	108.8	(7.1)	112	−0.94	
ME-TGO'(mm)	63.3	(5.3)	30	64.5	(5.1)	116	−1.14	
AR-TGO'(mm)	41.6	(4.4)	30	44.0	(5.2)	116	−2.59	**
Soft tissue								
S-n-ss°	89.7	(4.3)	30	86.7	(4.7)	115	3.27	*
S-n-sm°	80.2	(4.3)	30	80.4	(4.7)	115	−0.20	
S-n-pg°	80.6	(5.0)	30	82.0	(4.7)	115	−1.32	
ss-n-sm°	9.4	(2.3)	30	6.3	(2.3)	115	6.51	***
n-sn-pg°	155.9	(6.8)	30	164.2	(6.3)	115	−5.99	***
n-prn-pg°	125.5	(6.2)	30	133.5	(5.6)	115	−6.46	***
prn-sn-ls°	127.1	(10.3)	30	128.5	(10.6)	116	−0.64	
n-S(mm)	71.4	(4.7)	30	72.4	(4.3)	115	−1.08	
n-gn(mm)	113.7	(8.6)	30	113.9	(7.6)	115	−0.13	
n-sn(mm)	51.8	(4.9)	30	53.5	(3.4)	115	−1.77	
sn-gn(mm)	65.5	(6.2)	30	62.5	(6.0)	116	2.42	*
Nasopharynx								
AD1-PM(mm)	23.1	(3.8)	30	22.5	(4.1)	113	0.83	
AD2-PM(mm)	21.9	(4.3)	30	21.3	(4.1)	113	0.74	
AD1-BA(mm)	20.0	(4.4)	30	20.1	(3.2)	112	−0.14	
AD2-SO(mm)	16.9	(4.2)	30	16.5	(3.0)	113	0.42	
PM-BA(mm)	43.2	(4.4)	30	42.7	(3.8)	112	0.57	
HY-HY'(mm)	20.9	(5.7)	30	18.1	(5.1)	112	2.45	*
PAS(mm)	9.0	(2.8)	30	11.3	(3.4)	116	−3.71	***
HY-GN(mm)	43.2	(6.9)	30	45.5	(5.3)	112	−1.7	

Significance: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

significant difference in the craniofacial dimensions of the PRS group. The PRS patients with secondary palatal surgery had significantly larger sagittal depths of middle and upper airways (AD1-PM and AD2-PM) than did those without secondary repair.

Discussion

The PRS patients in this study comprise a portion of those in a previous mixed longitudinal study examining craniofacial morphology in PRS between 4 and 20 years of age (14, 15). The results of the present study support our previous finding that the mandible is more retrognathic in PRS than in ICP (14, 15), although this difference becomes smaller with age. Some true catch-up growth of the mandible may have occurred, as has been reported also in previous studies (12, 13, 16, 19, 20). It is of interest that the measurements of the soft-tissue mandible (S-n-sm, S-n-pg) were nonsignificant, which may result from the fact that the mandibular retrusion in PRS patients is partly masked by soft tissue. The muscular tonus of the symphysis area, depending on the lip closure at the moment of taking the roentgenogram, may also have affected the measurements. In this study orthodontic treatment may also have contributed to some spontaneous forward growth of the mandible, even though activator treatment was not used.

According to Pruzansky (12), antegonial notching in PRS patients increased after 9 years of age, causing more convexity in the facial profile. Our finding on the mandibular morphology in PRS patients compared with the ICP patients was reduced ramus length (AR-TGO'). This may enable the mandible to rotate further backwards as a compensatory effect against reduced size of the ramus during growth and to preserve dental occlusion. The shorter posterior cranial base length in the PRS group may also facilitate convex profile development. This agrees with the conclusion of da Silva Filho et al. (21) that clefts involving the palate are associated with more vertical growth of the face and other changes in mandibular shape (gonial angle) and, consequently, with a posterior rotation of the mandible.

The bony maxillary length (ANS-PM) was shorter in PRS, as has been reported at younger ages (14, 15). The maxillary sagittal and vertical relation to the cranial base did not differ significantly between the groups. On the other hand, the soft-tissue maxilla in the PRS group was more prognathic than in the ICP group, which makes the PRS soft-tissue profile more convex.

There were more complete and partial clefts of the palate in the PRS group than in the ICP group. The more severe clefts can be connected with more obvious skeletal growth disturbance, a more posteriorly positioned maxilla and mandible, and shorter maxillary length (17, 22, 23); and the greater disharmony in craniofacial growth in the PRS group could in part be due to the wider clefts. On the other hand, craniofacial morphology within the PRS group in this study did not vary significantly with regard to cleft extent. Associated anomalies were also commoner in the PRS group (20%) than in the ICP group (12%) but were not deviant, as reported in other studies (24–26). The difference in the distribution of operation methods between the Veau–Wardill–Kilner (VK) and Cronin (C) modification in the PRS and ICP group may also have had some effect on the results. In a previous study of the same ICP material the patients in the VK group differed from those in the C group with regard to cranial base and mandibular size (17). In the VK group the mandible was longer, and its ramus higher but less backwards rotated in that study. The mandibular size difference between the VK and C methods in ICP patients was in part explained by the age and sex difference of the groups (17). The role of the surgeon in the final growth must also be kept in mind in the present study (27). The C surgical method was percentually overrepresented in PRS group, which confuses the comparability of results. The age range of the PRS group was wider, and the mean age higher when compared with the ICP group. Therefore the postpubertal growth may be expected to have occurred in most of the PRS patients, whereas some of the ICP patients may still have had some growth left.

In our previous studies the patients with PRS needed velopharyngeal flaps because of their hypernasal speech more often (53%) than did the ICP patients (20%) (28). It has been shown that subjects with velopharyngeal flaps had significantly greater sagittal depths of the nasopharyngeal airway (AD1-PM, AD2-PM) (18). The results of this study on the PRS patients also support this. However, in our study the pharyngeal dimensions of the PRS group differed significantly from those of the ICP group only in the lower pharyngeal regions. The posterior air space was smaller and the hyoid bone position more inferior in PRS patients than in the ICP patients in young adulthood.

Tongue posture and respiration are also important when considering the facial growth. The differences in cranial base, mandibular inclination, size of the posterior airway space, and position of the hyoid bone might reflect differences in mode of respiration between the two groups and more mouth-breathing in the PRS group. Furthermore, secondary procedures for velopharyngeal insufficiency, such as pharyngeal flap, increase the prevalence of mouth-breathing. Cleft patients who need pharyngoplasty are reported to have a more posterior position of the tongue than do noncleft patients (29). In PRS infants the lowered and more posterior tongue position can cause airway obstruction and apneic episodes in breathing (7, 8). According to Figueroa et al. (5), tongue position and shape were specific to PRS when compared with those of ICP and normal children during their first 2 years.

Snoring is common in PRS infants and children (30). The cephalometric measurements specific to obstructive sleep apnea syndrome (OSA) in adults are lowered hyoid bone position, short PAS distance, greater soft-palate length, and increased skeletal vertical dimensions (31, 32). With regard to hyoid bone position and oropharyngeal dimensions, PRS and OSA show similarities, but the soft-palate length in the cleft patients, which was not studied here, may not fulfill the cephalometric criteria of OSA.

The craniofacial morphology of PRS in young adulthood seems to resemble greatly that of ICP with regard to the maxilla. The mandible is more retrognathic and more down- and backward-rotated in PRS. The shorter lower pharyngeal depth (PAS), with lowered tongue position in PRS, may be an inductive factor in the mouth-breathing model and destroy the muscle balance, leading to the typical PRS profile, or it may in some other way be the result of reduced growth potential in facial structures.

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Received for publication 4 December 1996
Accepted 12 February 1997