Differences In Craniofacial Morphology between Complete and Incomplete Unilateral Cleft Lip and Palate in Adults

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Differences in craniofacial morphology between complete and incomplete unilateral cleft lip and palate were studied in adult males by roentgenocephalometry. Incomplete clefts did not have the widening of the nasal cavity, reduction of the upper face height, or reduced thickness of the upper lip found in complete clefts. The shortening of maxillary depth was half that noted in complete clefts. The mandibular deviations and interorbital widening did not differ. The same held true for the retroinclination of upper incisors and alveolar process and backward shift of the maxilla. These changes accounted for differences in sagittal maxillo-mandibular relations, facial profile, occlusion of incisors and total facial height between complete and incomplete clefts. Limitation of anterior growth rotation of the face was identical. The independence of mandibular variations on the extent of the cleft and on maxillary malformation suggests the possibility of an underlying primary impairment of growth of the lower jaw, at least in some cases.

The present report deals with changes in craniofacial morphology in adults with unilateral cleft lip and palate related to the extent or completeness of the cleft. The purpose of this study was to determine which of the facial deviations were influenced and to what degree by the presence of a tissue or skeletal bridge across the cleft.

Materials and Methods

Data comparing individuals with cleft and a control group were presented in the previous report (Šmahel, 1982). There were 58 adult males of Czech origin with cleft lip and palate on the right side, of which 32 had a complete cleft and 26 an incomplete cleft; 10 with persisting tissue bridge at the lower margin of the nostril, and the other 16 with both a tissue and skeletal bridge across the anterior maxilla. The age range was 20 to 42 years, the mean age was 28.0 years in the subgroup with complete clefts and 26.1 years in the subgroup with incomplete clefts. The age at the time of surgical repair did not differ significantly between the subgroups of clefts: lip repair at 7.6 months in complete clefts and 8.9 months in incomplete clefts (t = 0.94); palate repair at 4.7 years and 5.2 years, respectively (t = 1.35). A uniform technique of surgical repair was used: The lip was repaired by the method of Veau, the palate by a pushback, usually including pharyngeal fixation as well. Patients with associated malformations or who had had facial osteotomy were excluded from the study.

The series of controls consisted of volunteers matched for age who were treated on because of injuries, as well as of university students. They were selected at random without an examination of the interrelation between the two jaws. Their mean age was 27.2 years and

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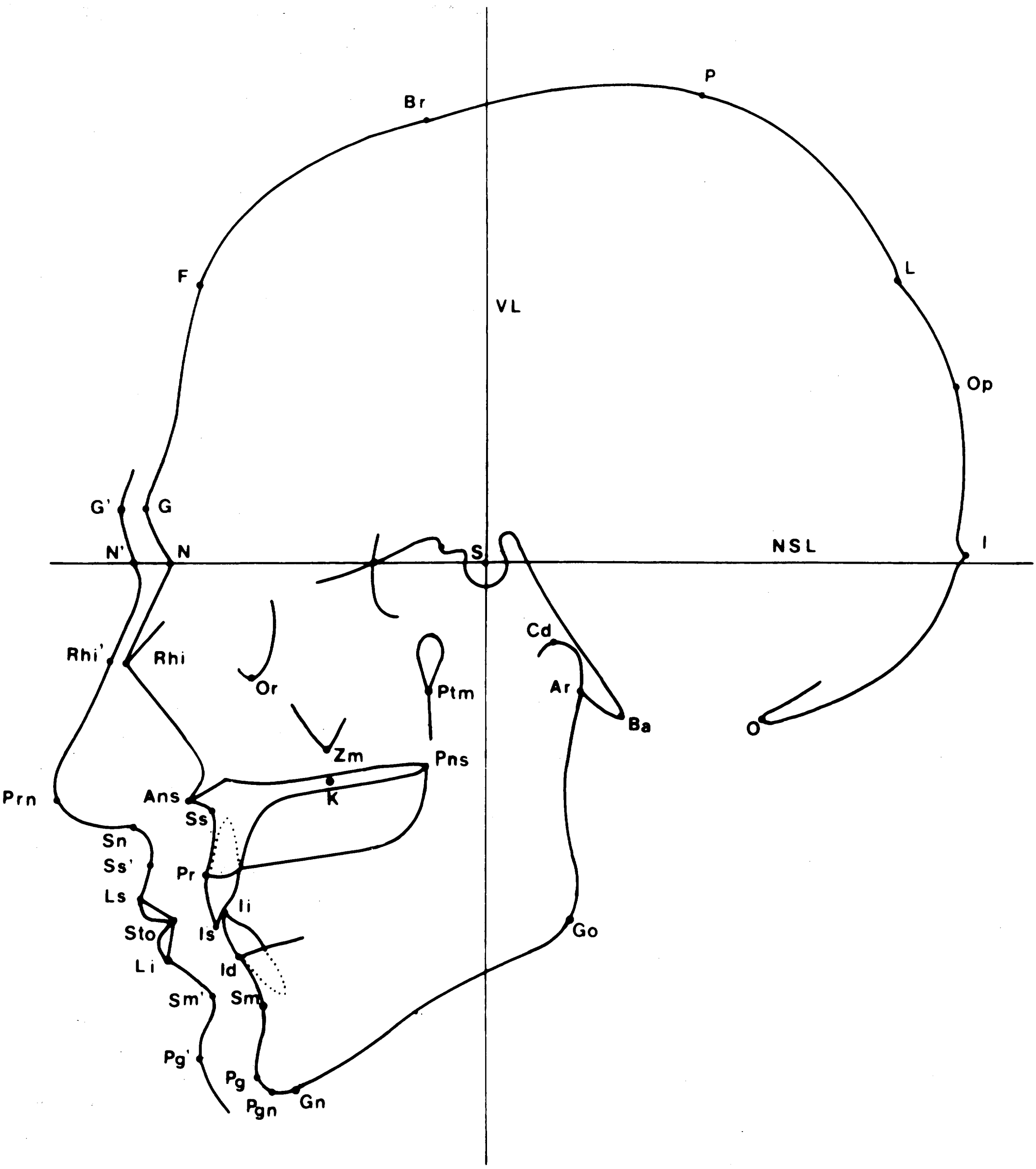

FIGURE 1. Cephalometric points used for the assessment of lateral X-ray films:
Ans—tip of the anterior nasal spine; **Ar** (articulare)—intersection of inferior contour of the clivus and posterior contour of the ramus; **Ba** (basion)—most posteroinferior point on the clivus; **Br** (bregma)—intersection of the coronal suture and lamina externa of the cranial vault; **Cd** (condylion)—most superior point on the condylar head; **F** (frontale)—intersection of the perpendicular to the dimension N-Br through its midpoint and lamina externa of the cranial vault; **G** (glabella)—most prominent point of the supraorbital ridges; **Ǵ** (soft glabella)—point on the soft profile contour over G parallel to NSL; **Gn** (gnathion)—lowest point of the mandibular symphysis; **Go** (gonion)—point on the angle of the mandible determined by the axis of ML/RL angle; **I** (inion)—top of the protuberantia occipitalis externa; **Id** (infradentale)—point of gingival contakt with lower central incisor; **Ii** (incision inferius)—incisal tip of the lower central incisor; **Is** (incision superius)—incisal tip of the upper central incisor; **K**—Zm projected on the palate line PL; **L** (lambda)—intersection of the lambdoid suture and lamina externa of the cranial vault; **Li** (labrale inferius)—margin of the vermilion of the lower lip, **Ls** (labrale superius)—margin of the vermilion of the upper lip; **N** (nasion)—most anterior point on the frontonasal suture; **Ń** (soft nasion)—intersection between NSL and soft profile contour; **O** (opisthion)—most posterior point of the foramen magnum located by the prolongation of the posterior wall of the spinal canal up to the occipital bone; **Or** (orbitale)—lowest point of the orbit; **Op** (opistho-

body weight and height corresponded exactly to the norms for our general population (176.9 cm and 77.2 g).

X-ray films were obtained under standard conditions (focus-object distance 3.70 m, focus-film distance 4.00 m). The head of the patient was fixed by a cephalostat and was inclined caudally about 15° from the Frankfort plane. The enlargement was 8.1%.

Craniometric points used in the study are presented in Figures 1 and 2, reference lines of lateral projection in Figure 3. On anteroposterior films the mediosagital line (MSL) was constructed with the method of a regression straight line (Figure 2). MSL proceeds from its starting point forming the central point between the apex of the crista galli (point No. 1) and one half of the biorbital distance Lo-Lo (point No. 2), between further three points: at half of the bizygomatic width (No. 3) and biantegonial width (No. 4) and at a point constructed by perpendiculars to the upper margin of the orbits (from the cristagalli) and to its lower margin (from the half of bizygomatic width), marked at a constant distance (No. 5). The horizontal line HL is then plotted perpendicular to MSL from the left Lo point.

The characteristics measured on lateral X-ray films are listed in Table 1a, b and c. Dimensions required only for construction purposes which did not attain the level of statistic significance are not included. The midpoint between projections of all bilateral landmarks was used where appropriate. Evaluation of AP projection is documented only by basic dimensions (Table 2) since only one of the characteristics differed significantly between complete and incomplete clefts. The perpendicular distance of a given point from the reference line is designated as Cd-NSL a.o. The thickness of soft tissues of the profile was measured in the region of the upper lip from points Sś and Pr parallel to the palate line (PL), and in the region of the lower lip from points Id and Sḿ representing the smallest thickness, and on the chin from point Pǵ perpendicular to the facial profile Line NṔǵ (mark Pgt́ etc.). On AP projection we measured in addition the projective minimum suborbital height of the maxilla in the region of zygomaticomaxillary suture (zy-max, arrow on Figure 2). The perpendicular distances of all landmarks from MSL and HL were measured as well and used for assessment of asymmetries (with the exception of Cr points measured as C-Cr dimensions). Deviations of medial facial structures (Intis, Id, Gn) were measured from MSL at point C.

Many individuals had lost incisor teeth, so the measurements involving maxillary incisor apex (Is) were available for 14 of the complete group and 18 of the incomplete group, and the mandibular incisor apex (Ii) for 24 of the complete and 23 of the incomplete.

The subgroups were compared with each other and with the controls by means of the F-test and the t-test. The series of clefts as a whole was subjected, in addition, to an analysis of some selected intracranial relations by means of the linear function ($y = a + bx$) and by the quadratic regressive function ($y = a + bx + cx^2$). The correlation coefficients were tested with the t-test as well.

Results

The results are summed up in Tables 1a, 1b, 1c, and 2. The basic bodily parameters (body height and weight, chest circumference and biacromial, bicristal and bitrochanteric widths) showed no differences between individual subgroups, but the circumference of

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cranion)—point on the surface of the cranial vault farthest from nasion; **P** (parietale)—intersection of the perpendicular to the dimension Br-L through its midpoint and lamina externa of the cranial vault; **Pg** (pogonion)—most anterior point on the bony chin; **Pǵ** (soft pogonion)—most anterior point on the soft tissue chin; **Pgn** (prognathion)—point on the mandibular symphysis farthest from Cd; **Pns**—tip of the posterior nasal spine resp. most posterior point of the palatal processes; **Pr** (prosthion)—point of gingival contact with upper central incisor; **Prn** (pronasale)—point on the top of apex nasi; **Ptm** (pterygomaxillare)—most inferior point of fossa pterygopalatina where fissura pterygomaxillaris begins; **Rhi** (rhinion)—most anteroinferior point on the nasal bone; **Rhí** (soft rhinion)—point on the soft profile contour over Rhi; **S** (sella)—centre of sella turcica; **Sm** (supramentale)—deepest point on the anterior contour of the mandibular symphysis; **Sḿ** (soft supramentale)—deepest point on the soft contour of the lower jaw; **Sn** (subnasale)—point at which columella merges with the upper lip; **Ss** (subspinale)—deepest point of the subspinal concavity; **Sś** (soft subspinale)—deepest point of the upper lip; **Sto** (stomion)—point of contact of the upper and lower lip; **Zm** (zygomaxillare)—apex of the convexity of the lower margin of os zygomaticum i.e. lower margin of sutura zygomaticomaxillaris.

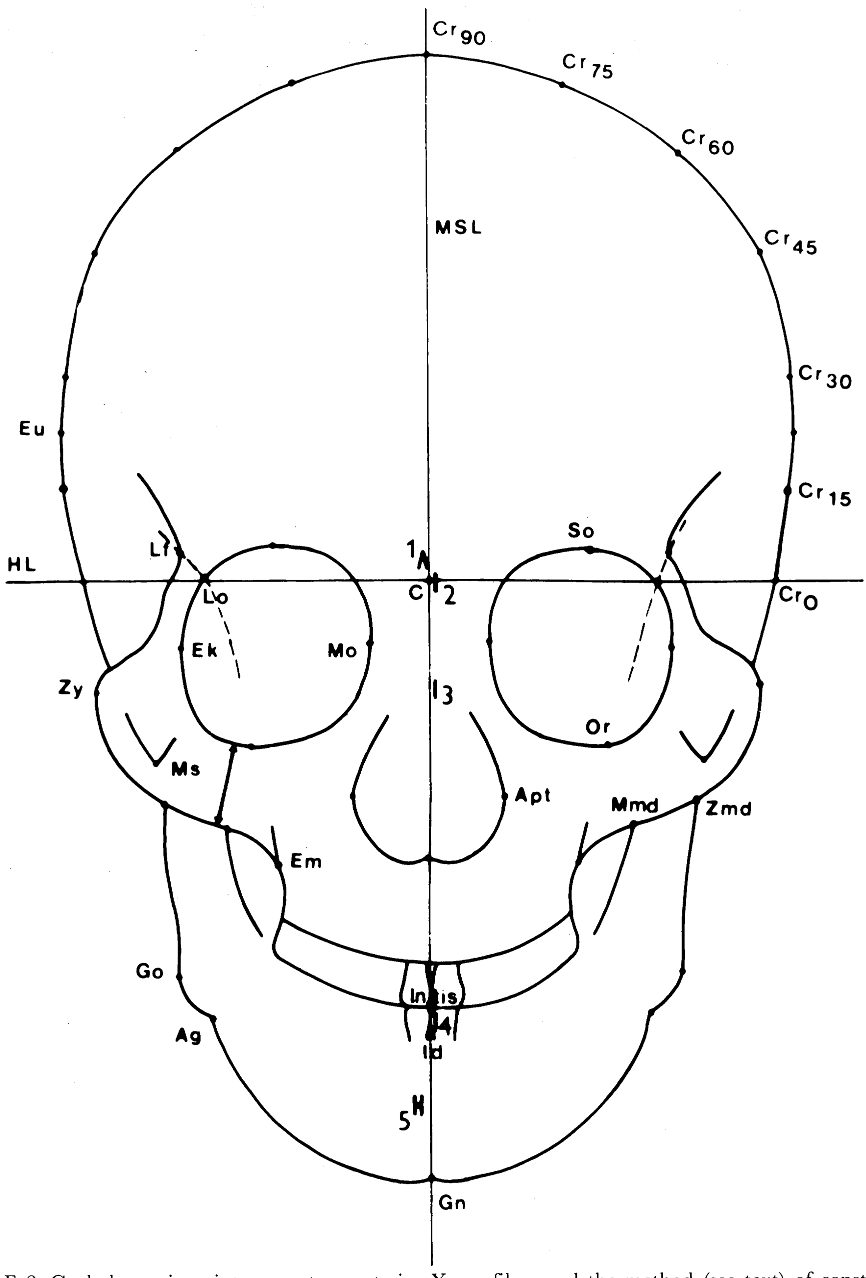

FIGURE 2. Cephalometric points on anteroposterior X-ray films and the method (see text) of construction of mediosagital line:
Ag (antegonion)—highest point in the antegonial notch; **Apt** (apertion)—most lateral point of the nasal cavity; **C**—intersection of MSL and HL; **Cr_{60}** (craniale)—intersection between lamina externa of the cranial vault and line drawn from point C under the slope of 60° from HL, etc; **EK** (ectoconchion)—most lateral point of the orbital contour; **Em** (ectomaxillare)—intersection of lateral contour of upper alveolar process and lower contour of maxillozygomatic process of the maxilla; **Eu** (euryon)—most lateral point of the cranial vault; **Gn** (gnathion)—notch of the center of the convexity of the mandibular lower margin; **Go** (gonion)—most lateral point of the mandibular angle; **Id** (infradentale)—bone margin between the lower medial incisors; **Intis** (interincision)—notch between incisal edges of the upper medial incisors; **Lf** (laterofrontale)—point of intersection between lateral margin of the ala major and lateral margin of the proc. zygomaticus of the frontal bone; **Lo** (lateroorbitale)—point of intersection between lateral margin of the ala major and contour of the orbita; **Mmd** (maxillomandibulare)—intersection between lower margin of the maxilla and medial contour of the mandibular ramus; **Mo** (medioorbitale)—most medial point of the orbital orifice; **Ms** (mastoideale)—top of the proc. mastoideus; **Or** (orbitale)—lowest point of the orbital orifice; **So** (supraorbitale)—highest point of the orbital orifice; **Zmd** (zygomandibulare)—intersection between lower margin of the zygomatic bone and lateral contour of the mandibular ramus; **Zy** (zygion)—most lateral point on the zygomatic bone.

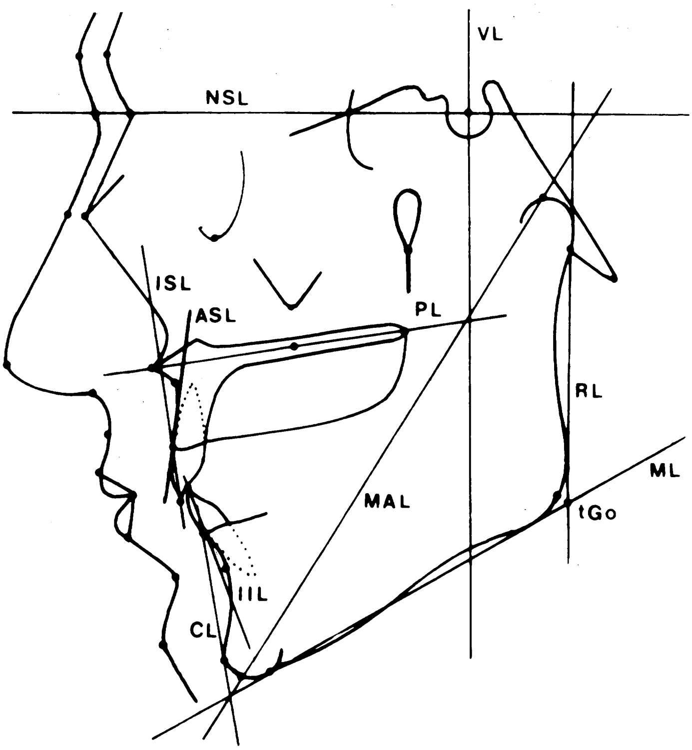

FIGURE 3. Reference lines plotted on lateral X-ray films (NSL = line through N and S, VL = perpendicular to NSL through S, PL = line through Ans and Pns, CL = line through Pg and Id, ML = tangent to the mandibular body through Gn, RL = tangent to the mandibular ramus through Ar, MAL = line through Pgn and Cd, ASL = tangent to the maxillar alveolar process through Pr, ISL = line through Is and Pr, IIL = line through Ii and Id, tGo = tangenta gonion point - intersection of ML and RL).

the head was significantly reduced in complete clefts (by 8 mm, $p < 0.05$), while in incomplete clefts the difference was 3.6 mm (Šmahel, 1982).

THE NEUROCRANIUM. There were no differences in the length (N-Op, N-I) and width (Eu-Eu) of the neurocranium between the subgroups or between the subgroups and the controls. A widening of the front was significant only in incomplete clefts (Lf-Lf, Table 2), while it was smaller in complete clefts. The height of the neurocranium (Ba-Br, Ba-L) was significantly less than normal only in complete clefts as was the shortening of the foramen magnum (Ba-O) and the posterior rotation of the cranial vault (N-S-Br, N-S-L, Op-NSL and I-NSL). The latter agreed with the marked reduction of the frontal bone slope (S-N-F) in complete clefts ($p < 0.001$) than in incomplete clefts ($p < 0.05$).

Thus it was possible to draw the conclusion that the reduction of the circumference of the head, the smaller height of the neurocranium and the less marked frontal slope were more pronounced in complete clefts while the frontal widening was larger in incomplete clefts (in complete clefts the widening was smaller in agreement with the smaller dimensions of the neurocranium). However the differences between the subgroups were not significant.

THE CRANIAL BASE. There were no significant differences of the configuration of the cranial base between complete and incomplete clefts. The anterior part of the cranial base (N-S) was shortened in both subgroups while length of the posterior part (S-Ba) and curvature of the base (N-S-Ba, N-S-Cd) did not differ from controls.

BONY FRAMEWORK OF THE NASOPHARYNX. Its depth (Pns-Ba) was reduced in the same way in both subgroups, while its height (S-Pns) was significantly reduced in complete

TABLE 1a. *Linear Measurements.* The Mean Values of the X-ray Cephalometric Characteristics in Lateral Projection in Adult Males with Complete Clefts (CLP_c) and Incomplete Clefts (CLP_i), as Compared to Controls. (+ = Significant Differences Between Complete and Incomplete Clefts, x = Significant Differences Between Clefts and Controls)

	CLP_c	CLP_i	*Control*		CLP_c	CLP_i	*Control*
Cranium				*Facial height*			
N-Op	190.4	190.2	191.6	N-Rhi	27.9^{xxx}	26.9	24.9
N-I	186.9	187.5	188.9	$N\text{-}Ans^{+}$	54.1^{xxx}	56.7	57.1
Ba-Br	148.2^{xxx}	150.5	152.5	$N\text{-}Ss^{++}$	57.9^{xx}	60.8	60.4
Ba-L	122.1^{x}	124.4	125.1	N-Pr	74.1	76.0	75.4
Ba-O	35.8^{x}	37.0	37.5	N-Gn	132.6	134.9^{xx}	130.2
Op-NSL	35.2^{xx}	39.5	42.7	Is-PL	31.9	31.3	30.8
I-NSL	-5.2^{x}	−4.0	0.7	Pr-PL	19.2	18.8	18.3
N-Ba	111.3^{x}	112.7	113.8	Ii-Gn	47.3	48.9^{xx}	45.9
N-S	73.2^{x}	73.4^{x}	75.0	Id-Gn	36.3^{x}	36.9^{x}	34.5
S-Ba	49.2	49.7	49.3	Pr-Id	23.7^{xxx}	23.2^{xxx}	21.3
Facial depth				Ans-Pg	73.1^{xxx}	73.3^{xxx}	67.7
$Ss\text{-}Pns^{+}$	47.1^{xxx}	49.4^{xx}	52.4	S-Go	85.2^{x}	87.1	88.1
$Ans\text{-}Pns^{+}$	51.2^{xxx}	54.1^{xx}	56.7	S-Pns	48.7^{xx}	49.7	50.9
$Ans\text{-}K^{+}$	28.9^{xxx}	31.4	32.0	Pns-NSL	47.2^{x}	48.8	48.9
Pns-K	21.9^{xx}	22.9^{x}	24.6	Or-NSL	27.8	28.9	28.1
Pns-Ba	44.6^{xxx}	45.6^{xxx}	48.5	$Zm\text{-}NSL^{++}$	46.6^{xx}	48.8	48.6
Ptm-VL	11.5^{xx}	11.9^{x}	13.7	Ptm-NSL	31.3^{xx}	31.5^{x}	33.4
Pns-VL	12.0^{xx}	11.4^{xx}	14.3	*Mandible* (ramus)			
Mandible (body)				Cd-Go	64.2^{xx}	66.0	67.4
Pgn-tGo	77.0^{xx}	77.9^{x}	80.7	Ar-tGo	53.5^{xxx}	55.1^{x}	57.8
Pgn-Go	75.7^{x}	76.7	79.0	Cd-NSL	19.2	18.9	19.2

$^{x}p < 0.05$ $^{xx}p < 0.01$ $^{xxx}p < 0.001$

TABLE 1b. *Angular Measurements.* The Mean Values of Lateral Projection—Angles (Explanatory Notes See Tab. 1a)

	CLP_c	CLP_i	*Control*		CLP_c	CLP_i	*Control*
Cranium				*Upper face*			
S-N-F	81.9^{xxx}	83.1^{x}	85.0	PL/NSL	6.5	8.2	8.0
N-S-Br	84.4^{x}	84.0	82.2	ASL/PL	95.6^{xxx}	99.0^{xxx}	107.6
N-S-L	148.2^{xxx}	146.2	144.1	ISL/PL	84.2^{xx}	84.1^{xx}	92.3
N-S-Ba	130.3	131.4	132.2	N-S-Pns	75.8^{x}	76.9^{xx}	73.8
S-Ba-O	128.6	128.7	128.9	S-N-Or	52.7^{x}	52.7^{x}	54.6
Profile				S-N-Zm	50.1^{xxx}	50.7^{xx}	53.4
S-N-Rhi	108.4^{xxx}	109.9^{xx}	115.3	*Mandible*			
$S\text{-}N\text{-}Ans^{+}$	78.2^{xxx}	81.0^{xxx}	85.2	ML/NSL	37.0^{xxx}	36.6^{xxx}	30.1
S-N-Ss	74.6^{xxx}	76.4^{xxx}	80.7	ML/RL	129.0^{xxx}	128.5^{xxx}	122.0
S-N-Pr	76.6^{xxx}	78.0^{xxx}	82.9	CL/ML	64.0^{xxx}	65.5^{xxx}	70.8
S-N-Id	77.4^{xx}	77.7^{x}	80.1	RL/NSL	87.9	88.3	88.2
S-N-Sm	75.9^{x}	76.0^{x}	78.2	MAL/NSL	61.0^{xx}	61.6^{xx}	58.2
S-N-Pg	77.8^{x}	77.7^{x}	79.8	PL/ML	30.5^{xxx}	28.4^{xxx}	22.0
S-N-Gn	74.6^{x}	74.4^{x}	76.5	IIL/ML	66.5^{xxx}	68.9^{xxx}	79.6
$Ss\text{-}N\text{-}Sm^{+}$	-1.3^{xxx}	0.4^{xx}	2.5	IIL/NSL	76.8^{xx}	73.9	70.8
$Ss\text{-}N\text{-}Pg^{+}$	-3.2^{xxx}	-1.3^{xx}	0.8	N-S-Cd	130.3	131.5	131.1
$N\text{-}Ss\text{-}Pg^{+}$	185.5^{xxx}	181.9^{xx}	178.1	N-S-Pgn	71.1^{xx}	71.6^{xx}	68.5

TABLE 1c. *Soft Tissue Profile Measurements.* The Mean Values of Lateral Projection—Dimensions of the Soft Profile (Explanatory Notes See Tab. 1a)

	CLP_c	CLP_i	Control		CLP_c	CLP_i	Control
Height				*Angle*			
N′-Prn	58.2	60.3	59.3	S-N′-Pg′	79.9^{x}	80.1^{x}	82.3
N′-Sn^{+}	62.3	64.6	64.0	Ss′-N′-Sm′$^{++}$	2.0^{xxx}	4.2^{xxx}	7.2
N′-Sto^{+}	84.7^{x}	87.2	86.8	Ss′-N′-Pg′$^{++}$	−0.4^{xxx}	2.0^{xxx}	4.7
N′-Pg′	121.1	124.1^{x}	120.4	N′-Sn-Pg′$^{+}$	177.3^{xxx}	172.2^{xxx}	164.6
Sn-Ls	15.4^{xxx}	15.2^{xxx}	17.7	N′-Prn-Pg′	144.8^{xxx}	141.5^{xxx}	134.0
Sn-Sto	22.0^{xxx}	22.9^{x}	24.3	*Thickness*			
Depth				N-N′	9.2	8.8	9.3
Prn-Sn	19.6	19.3	20.0	Sst′	13.7^{xx}	14.5	14.8
Prn-Ans	29.8^{xxx}	29.2^{xxx}	32.3	Prt	14.2^{x}	14.9	15.3
Angle				Idt	11.4	11.4	11.6
S-N′-Ss′$^{+}$	79.6^{xxx}	82.2^{xxx}	87.1	Smt′	11.9	12.2	12.3
S-N′-Sm′	77.6^{xx}	77.9^{x}	79.9	Pgt′	14.5	14.7	14.7

TABLE 2. The Mean Values of Anteroposterior Projection (Explanatory Notes see Table 1a)

	CLP_c	CLP_i	Control		CLP_c	CLP_i	Control
Cranium				*Upper face*			
Eu-Eu	161.5	163.6	163.4	Zy-Zy	147.5	148.0	147.2
Ms-Ms	117.8^{x}	120.5	120.4	Mo-Mo	29.8^{xxx}	29.8^{xxx}	26.9
Lf-Lf	111.1	112.4^{xx}	109.3	Lo-Lo	103.6^{x}	103.8^{x}	101.6
Mandible				Ek-Ek	110.4	110.9	109.7
Go-Go	111.5	111.7	112.6	Apt-Apt^{++}	37.6^{xxx}	35.1	34.7
Ag-Ag	99.7	99.7	98.0	Em-Em	69.2	68.0	68.4
Zy-Go dx	64.0^{xx}	65.2	67.5	zy-max dx	16.8^{x}	18.5	18.7
Zy-Go sin	63.8^{x}	64.8	66.9	zy-max sin	17.4	18.6	18.6

Index interorbitalis = 100 × Mo-Mo : Ek-Ek = 26.9^{xxx} 26.8^{xxx} 24.6

clefts only (since in incomplete clefts the posterior height of the upper face Pns-NSL was not shortened). But the difference between the two subgroups did not attain the significance level.

UPPER FACE. The orbital region was not affected by the extent of the cleft. The widening of the interorbital (Mo-Mo) and biorbital (Lo-Lo) width as well as proportional deviation (index interorbitalis) were identical in both subgroups. A highly significant difference between both subgroups showed the increased width of the nasal cavity (Apt-Apt), which occurred only in complete clefts. The bizygomatic width (Zy-Zy) and the width of the alveolar arch at its base (Em-EM) were unchanged.

The other significant deviations concerned height and depth dimensions (Figure 4). Height values were reduced in complete clefts alone (anterior N-Ans, lateral Zm-NSL and posterior Pns-NSL) and the differences between the subgroups were significant (N-Ans, N-Ss, Zm-NSL). Similar relations were found on the soft profile (Ń-Sn and Ń-Sto $p < 0.05$ between the subgroups). A shortening of the anterior height of the upper face (N-Ans) amounted to five per cent in complete clefts and to one per cent in incomplete clefts. The suborbital height of the maxilla in the region of sutura zygomaticomaxillaris (zy-max) was reduced, equally, only in complete clefts. The difference was significant on the involved side. The dentoalveolar height (Is-PL, Pr-PL) was

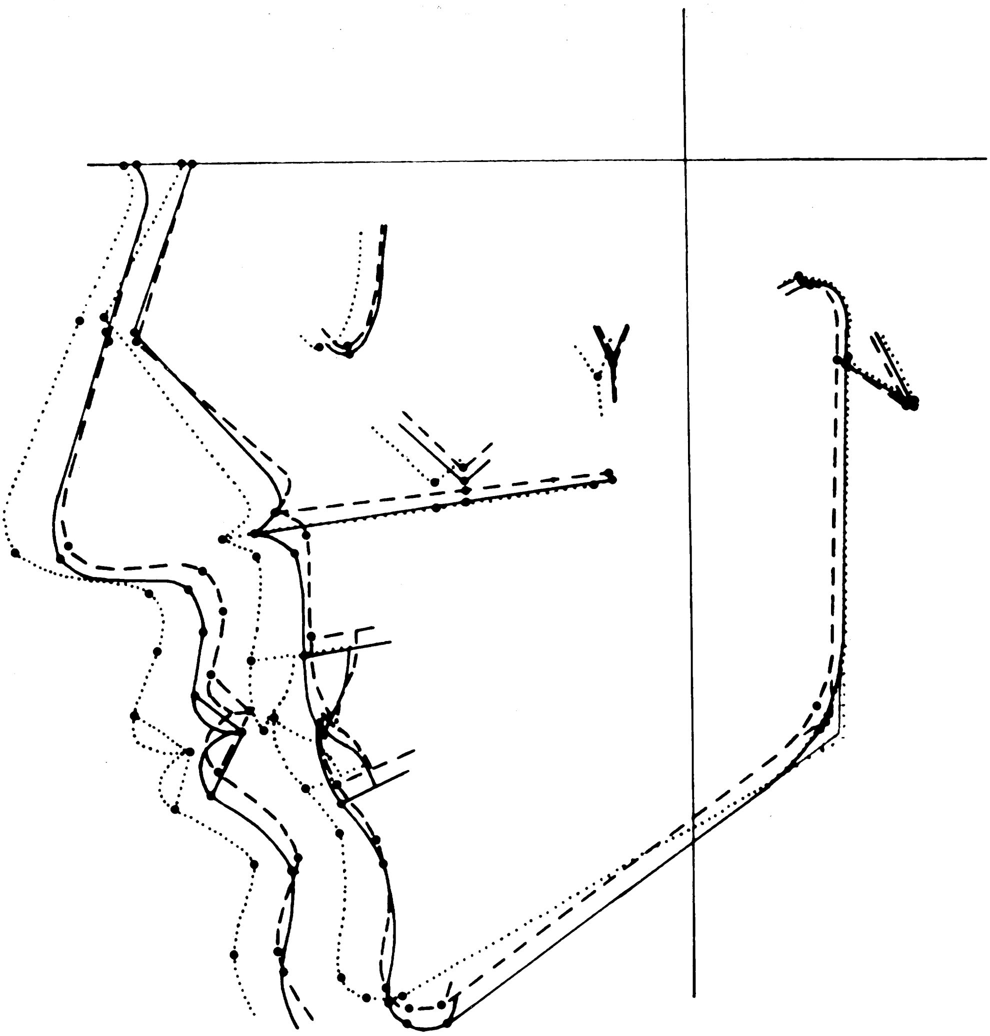

FIGURE 4. Faciograms in lateral projection (dashed line = complete cleft lip and palate, solid line = incomplete cleft lip and palate, dotted line = controls).

not reduced in our subgroups, the prolongation of nasal bones (N-Rhi) was significant in complete clefts only. The vertical dimensions in incomplete clefts thus were identical with those in controls.

The depth of the maxilla (Ans-Pns, Ss-Pns) differed significantly between the subgroups, as well as when they were both compared with the controls. In complete clefts the shortening amounted to as much as ten per cent, and in incomplete clefts to 5-6 per cent. This difference was due exclusively to the anterior segment (Ans-K). This was in agreement with the fact that in complete clefts the tissue bridge was missing in this very region. Therefore the retrusion within the lateral parts of the face was virtually identical in both subgroups (S-N-Or, S-N-Zm), while in the mediosagittal plane a more marked retrusion of the maxilla was present in complete clefts, as compared to incomplete (S-N-Ans, S-N-Ss, S-Ń-Sś). A posterior shift of the maxilla (Pns, VL, Ptm-VL) was identical in both subgroups, the slope of the palatal plane remained unchanged (PL/NSL).

The retroinclination of the alveolar process

(ASL/PL) was somewhat more pronounced in complete clefts (by 3.5°), yet the difference from the corresponding value in incomplete clefts was not significant. The retroinclination of the incisors was identical in both subgroups (ISL/PL).

The comparison of the two subgroups disclosed that changes within the orbital region were not related to the extent of the cleft, while the other maxillary deviations were regularly more marked in complete clefts (with the exception of the dentoalveolar retroinclination and the posterior displacement of the maxilla).

THE MANDIBLE. The differences between the two subgroups visualized on lateral faciogram (Figure 4) resulted mostly from higher position of the lower jaw, as documented by Figure 5. As compared to controls typical deviations were obvious. They consisted of shortening of the mandibular body (Pgn-Go, Pgn-tGo) and ramus (Cd-Go, Ar-tGo), elongation of anterior mandibular height (Ii-Gn,Id-Gn), obtuse gonial angle (ML/RL), acute chin angle (CL/ML), steeper slope of the body (ML/NSL), retroinclination of incisors (IIL/ML, IIL/NSL) and posterior (clockwise) growth rotation (MAL/NSL) and retrognathia of the mandible (S-N-Id, S-N-Sm, S-N-Pg, S-Ń-Sḿ, S-Ń-Pǵ). However, the comparison of the two subgroups revealed only insignificant differences inclusive of the length of the ramus (Cd-Go) showing on the average a shortening by 3.2 mm ($p < 0.005$) in complete clefts, as compared to 1.4 mm (insignificant) in incomplete clefts (the same relation was evident in AP projection: Zy-Go). The difference of 1.8 mm was most probably related to the more marked malocclusion within the frontal segment of the denture in complete clefts, which was in good correlation with the shortening of the mandibular ramus (see below). The width of the mandible (Go-Go, Ag-Ag), the position of the mandibular joint (Cd-NSL, N-S-Cd) and the inclination of the ramus (RL/NSL) were unchanged in both subgroups.

In summing up our results it was possible to state that while the maxilla showed significant differences of most characteristics between both subgroups, the mandibular deviations though marked did not show a dependence on the extent of the cleft.

FACIAL PROFILE. Because of the same mandibular retrusion in both subgroups, a more marked maxillary retrusion in complete clefts resulted in this subgroup in higher degree of flattening of the skeletal facial profile (N-Ss-

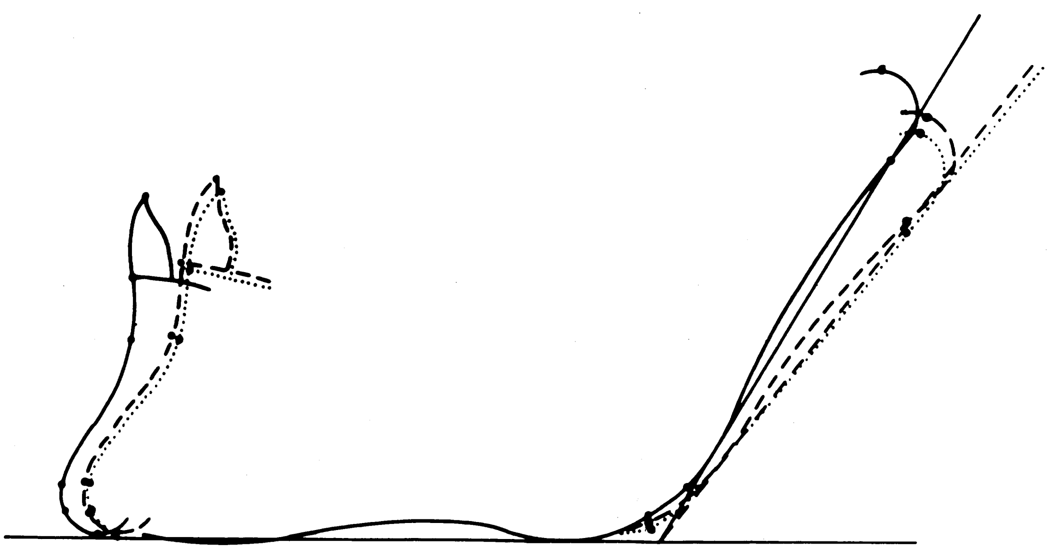

FIGURE 5. Morphograms of the mandible (dotted line = complete cleft lip and palate, dashed line = incomplete cleft lip and palate, solid line = controls).

Pg) and in a more marked impairment of sagittal maxillo-mandibular relations (Ss-N-Sm, Ss-N-Pg). As compared to incomplete clefts the differences were significant. The soft profile showed even more marked differations between the two subgroups (Ń-Sn-Pǵ, Sś-Ń-Sḿ, Sś-Ń-Pǵ) which were due to the reduction of the upper lip thickness occurring exclusively in complete clefts (at the level of Sś and Pr). The reduction of the height of the upper lip (Sn-Ls, Sn-Sto) and of the distance between the apex nasi and anterior spina (Prn-Ans) was similar in both subgroups. These similarities represented probably the sequelae of more frequent secondary surgical repairs of the lip and nose in complete clefts (performed in 90 per cent of the patients as compared to 40 per cent in incomplete clefts). The depth of the nose (Prn-Sn) was unchanged in both subgroups.

Facial asymmetry. In complete clefts a single characteristic of anteroposterior projection was significantly smaller on the affected side than on the normal side, i.e. the half of the width of the upper alveolar arch (Em-MSL dx:sin $p < 0.05$). This dimension was symmetrical in individuals with incomplete clefts. The deviation could reflect a medial displacement of the lateral alveolar segment on the affected side. Medial structures of the lower face (points Intis, Id and Gn) were not deviated.

The face as a whole. The anterior height of the face (N-Gn) was increased by 4.7 mm in incomplete clefts, and only by 2.5 mm in complete clefts. The soft profile yielded a similar finding (Ń-Pǵ). A characteristic prolongation of the face in patients with clefts was thus present in a slighter malformation alone, since the shortening of the upper face in complete clefts was so marked that it "compensated" to a large degree the prolongation of the lower face which was identical in both subgroups (Ans-Pg). The posterior height of the face (S-Go) was reduced only in complete clefts. The ratio of the anterior and the posterior height of the face was very similar in both subgroups (64.2 per cent in complete clefts and 64.6 per cent in incomplete clefts) since both dimensions were reduced in the same proportion in complete clefts as compared to incomplete clefts. Thus the anterior growth rotation (counterclockwise) of the face was reduced in the same degree (67.7% in controls).

The impairment of maxillo-mandibular relations in sagittal direction caused the inversion of incisors within the frontal segment of the denture in complete clefts (together with dentoalveolar retroinclination of the maxilla). Since this disproportion (Ss-N-Sm) was less marked in incomplete clefts, it was compensated in many cases by the dentoalveolar component of the lower jaw and an edge to edge bite was found in average patients. Because of these occlusion changes the distance Pr-Id was increased (similarly in complete and incomplete clefts). The vertical maxillo-mandibular relations (PL/ML) showed almost the same degree of impairment in both subgroups.

Discussion

Incomplete clefts represent a lesser degree of involvement. Thus in these clefts some deviations from normal are less or absent, while others are not related to the degree of the malformation. In the presence of a tissue bridge over the cleft there is neither a widening of the nasal cavity, a reduction of the upper face height, nor a reduced thickness of the upper lip. The lesser degree of shortening of maxillary depth leads also to smaller changes of the soft profile, of the sagittal maxillo-mandibular relations and of the occlusion, as well as to less retrocheilia. In the upper jaw, only the dentoalveolar retroinclination and posterior displacement of the maxilla were identical with that recorded in complete clefts (the latter may represent the result of the same technique of surgical repair). The relations within the orbital region and the mandibular changes remain uninfluenced by completeness of the cleft. The dimensions of the neurocranium are reduced in complete clefts and it remains a subject of speculation whether it is due to a malformation of the skull as a whole.

The presence of a tissue bridge in a cleft lip and palate thus exerted an important influence on three of five basic changes of the craniofacial complex, i.e., the depth, height and width dimensions of the upper jaw. Because of the partial maintenance of the continuity of the upper lip and jaw, this region was better capable of resistance to secondary effects which played an essential role in the development of maxillary retrusion. The shortening of the depth of the upper jaw was reduced by one half as compared to complete clefts. This difference was caused actually by the anterior segment alone (Ans-K) which was overbridged. The complete isolation of the affected side from growth impulses by the nasal septum might cause vertical growth impairment of the upper face in complete clefts while maintenance of the continuity of the alveolar process resulted in normal vertical growth in incomplete clefts. For the same reasons the nasal cavity showed no widening in the presence of a tissue bridge. On the contrary the interorbital distance was increased in both subgroups and thus was not related to the width of the nasal cavity as stated by Moss (1971). This was compatible with the hypothesis on the primary association with cleft lip (Dahl 1970, Aduss et al. 1971). The prolongation of nasal bones was more marked in complete clefts, which was most probably related to the more marked retrusion of the middle face (the correlation between N-Rhi and S-N-Ss was significant at $p < 0.05$). The fourth basic deviation, the dentoalveolar retroinclination of the maxilla did not show any significant differences between the two subgroups, which was probably due to the similar tension of the repaired lip in both groups.

Changes of the lower jaw were not affected by the extent of the cleft. Differences between the two subgroups showed only the length of the ramus, with a minimum shortening in incomplete clefts. This difference was most probably related to the more marked malocclusion within the frontal region of the denture in complete clefts as illustrated by the following analysis.

The total series of our patients was subdivided according to the occlusion of their incisors into three groups: normal overbite ($n = 12$), mandibular overbite and edge-to-edge bite ($n = 20$) and a group of the most unfavourable cases where even a prosthesis failed to attain an adequate repair of the bite ($n = 10$; the other patients treated by prosthetic repair were not included into the analysis). The results disclosed (Table 3) that increasing malocclusion in the frontal region of the denture was accompanied by a shortening of the mandibular ramus and a prolongation of the mandibular body. Thus the total length of the lower jaw given by the sum of its two parts showed only slight changes (the type of the bite definitely did not exert an effect on the mandibular growth potency). The shortening of the ramus resulted, necessarily, in a more obtuse mandibular angle (ML/RL) with a simultaneous definite displacement of the temporomandibular joint forwards and downwards (N-S-Cd, Cd-NSL). Changes of the cranial base angle (N-S-Ba) were not clearly evident, but the maxillary depth (Ss-Pns) was slightly greater in a more favorable bite. Thus the type of occlusion of the incisors was associated with the different ratio between the length of the body and the ramus (in favor of the body in the presence of impaired overbite).

The fact that mandibular deviations showed only little dependence on maxillar malformations was confirmed by the findings obtained in individuals without any surgical repair with normal protrusion of the upper jaw, but with deviations of the lower jaw, inclusive of retrognathia and steeper slope of mandibular body (Ortiz-Monasterio et al. 1959, Bishara et al. 1976). An identical pattern yielded the analysis of the relation between the most marked changes of both jaws in clefts i.e. the mandibular angle and maxillary depth (Figure 6). In clefts larger maxillary depth was not associated with a more acute gonial angle, as in controls ($r = -0.318$, $p < 0.025$) but with a rather slightly obtuse angle ($r = 0.096$). The comparison of both correlation coefficients (after z-transforma-

TABLE 3. The Mean Values of the Characteristics of the Mandible in Patients with Clefts According to the Type of Incisors Occlusion (I = Overbite, II = Mandibular Overbite or Edge-to-Edge Bite, III = Failed Prostetic Repair)

	n	*Pgn-Go*	*Cd-Go*	*Pgn-Go + Cd-Go*	*ML/RL*	*Cd-NSL*	*N-S-Cd*	*N-S-Ba*	*Ss-Pns*
I.	(12)	73.92	65.67	139.59	124.83	18.00	134.17	131.33	48.83
II.	(20)	75.80	65.15	140.95	130.75	18.95	130.45	131.60	47.68
III.	(10	78.50	63.80	142.30	131.00	21.10	125.90	127.90	47.00

The other prostetically repaired patients ($n = 16$): Pgn-Go = 76.88 mm and Cd-Go = 65.12 mm.

tion) showed a significant difference (t = 2.13, $p < 0.05$). This illustrated that in patients with clefts the growth of the lower jaw lacked the potency which would correspond to a normal developmental pattern. The fact that the development of the mandible was independent on the malformation of the maxilla was documented by individuals with a severe degree of maxillary retrusion associated with a normal development of the lower jaw (Figure 8).

On the basis of the above described observations showing developmental independence of the mandible, we believe that the reduction of the size of the lower jaw in clefts represents, to a large degree, a primary growth deficiency, which could induce the development of cleft palate during the third critical period (Jelínek and Peterka, 1977). The changed configuration was due, subsequently, to an adaptation to the deficient growth. Some investigators believed that a more obtuse gonial angle resulted from the hypofunction of muscles of mastication (Vora and Joshi, 1977 a.o.). However, it was also possible that it was caused by the primary shortening of the ramus which necessarily resulted in an obtuse

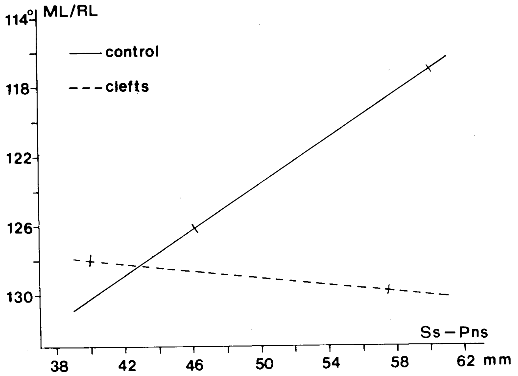

FIGURE 6. The relation between maxillar depth (Ss-Pns) and the mandibular angle (ML/RL) expressed in terms of linear regression (abscissa on the straight line = $\bar{X} \pm 2SD$ of maxillar depth).

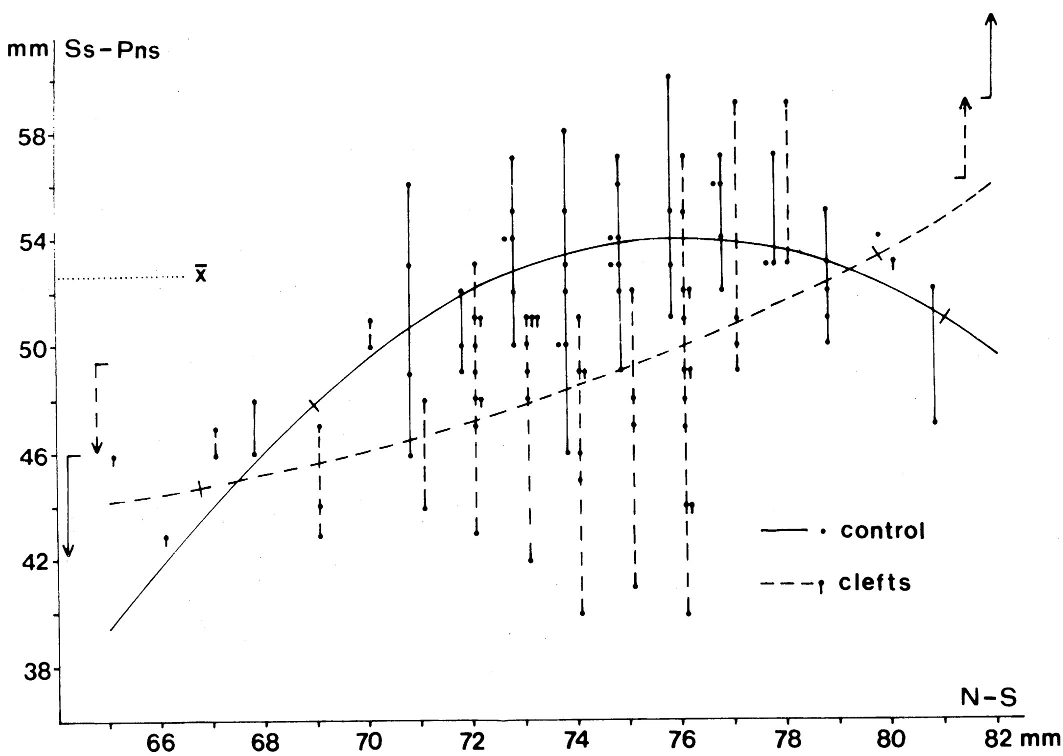

FIGURE 7. Relation between the length of the presellar part of the cranial base (N-S) and the depth of the maxilla (Ss-Pns) - distribution of the measurements and regression curves (on the curves the abscissa marks the range $\bar{X} \pm 2SD$). On the basis of measurements of controls the mean maxillar depth ($\bar{X}$) and the range ± 1 up to ± 2SD is represented by the dashed arrows and ± 2 up to ± 3SD by solid arrows.

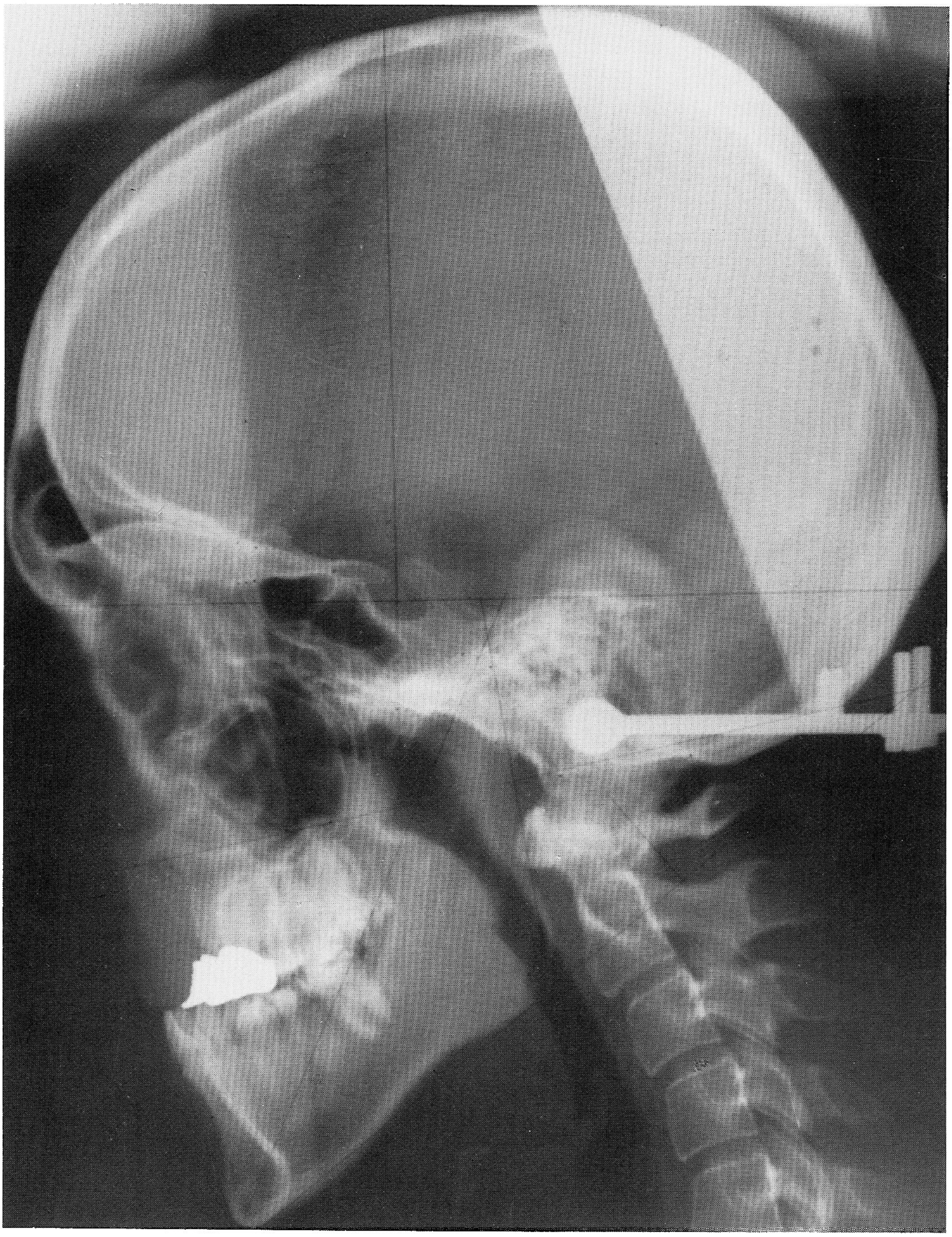

FIGURE 8. X-ray film in a patient with unilateral cleft lip and palate: in spite of the marked maxillar defect a normally developed mandible.

gonial angle, a steeper slope of the body and in an adaptive more acute chin angle, as well as in the increase of anterior mandibular height (Figure 9). These correlations were generally confirmed in a separate study (Škvařilová and Šmahel, in press).

Another type of interrelation was noted between the depth of the upper jaw and the

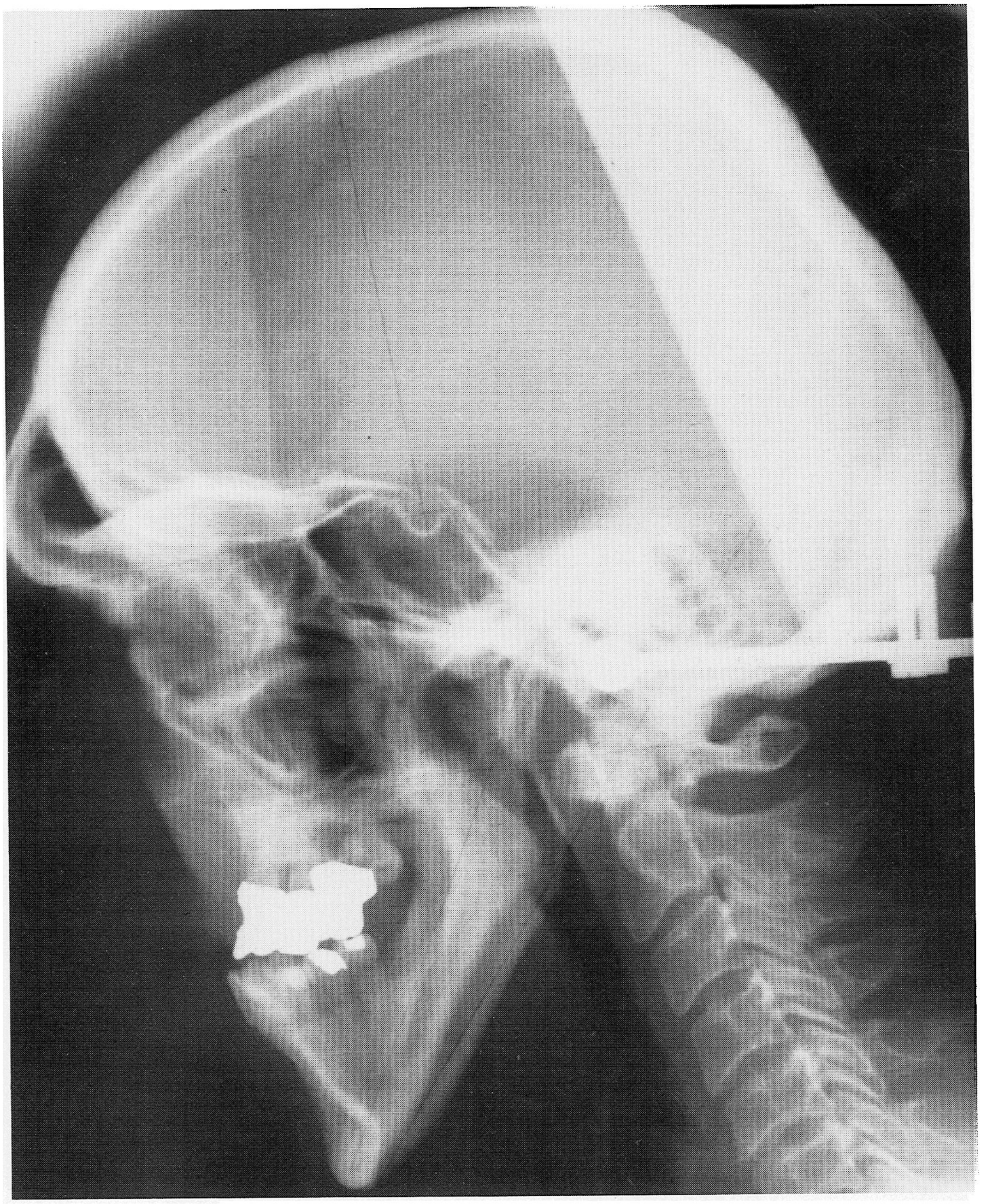

FIGURE 9. X-ray film in a patient with unilateral cleft lip and palate: the short ramus resulting in an oblique body, flattening of the gonial angle, an acute chin angle and an increased anterior height of the mandible.

length of the anterior part of the cranial base (Figure 7). The greater length of the anterior part of the cranial base was associated in controls with a larger depth of the maxilla, but only up to a certain borderline value (76 mm), while higher values were associated with a decrease of maxillary depth. This relation was well illustrated by the quadratic function of a parabole ($r = 0.509$). However, it was not clear why a long anterior part of the cranial base was associated with decreasing maxillary depth. In clefts the investigated relation was illustrated by a parabola (r = 0.437) as well, but with a very slight curvature and in an opposite direction. The upper jaw depth increased slowly with the length of the anterior part of the cranial base. When the length of the latter exceeded 76 mm, however, we failed to disclose in clefts any short (more than -2 SD), or shortened (-1 to -2 SD) depth of the upper jaw (Figure 7). The difference between both relations was significant, another type of interrelation in clefts showed the presence of an impairment of the further postinitial development of maxillary depth.

We are well aware of the very long time interval and of the spatial dimensional differences between the studied final state and the initial time of onset of the malformation. However the development proceeds conceivably under the control of genetic factors and it should therefore be possible to determine its basic characteristics in individual phases. In case of some other type or trend of the investigated relations, and not solely a shift towards lower or higher values, it indicates that the developmental changes are more permanent and more profound. Therefore we are of the opinion that the analyses of intracranial relations, especially during the developmental period, could prove helpful in the detection of causes of these changes. However during the interpretation of the results some other factors should be kept in mind, including in particular the secondary effects of therapeutic measures which should be determined by comprehensive studies.

To our knowledge no other reported study has dealt with assessments of craniofacial changes in clefts with regard to the completeness of the cleft, and no data are available for the comparison. Our findings disclose some significant differences, especially in the region of the upper jaw, which deserve special attention. Thus the presence of the tissue bridge favorably influences the growth and development of the maxilla in the characteristics which show the most marked effect of the cleft malformation.

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References

ADUSS, H., PRUZANSKY, S., and MILLER, M., Interorbital distance in cleft lip and palate, *Teratology, 4:* 171–181, 1971.

BISHARA, S. E., KRAUSE, CH. J., OLIN, W. H., WESTON, D., VAN NESS, J., and FELLING, CH., Facial and dental relationships of individuals with unoperated clefts of the lip and/or palate, *Cleft Palate J., 13:* 238–252, 1976.

DAHL, E., Craniofacial morphology in congenital clefts of the lip and palate, *Acta Odont. Scand., 28:* Suppl. 57, 1970.

JELÍNEK, R., and PETERKA, M., The role of the mandible in mouse palatal development revisited, *Cleft Palate J., 14:* 211–221, 1977.

MOSS, M. L., Facial growth: The functional matrix concept. In: Cleft lip and palate, ed. W. C. Grabb, S. W. Rosenstein and K. R. Bzoch. Boston: Little, Brown and Co., 1971.

ORTIZ-MONASTERIO, F., REBEIL, A. S., VANDERRAMA, M., and CRUZ, R., Cephalometric measurements on adult patients with non-operated cleft palates, *Plast. Reconstr. Surg., 24:* 53–61, 1959.

ŠVAŘILOVÁ B., and ŠMAHEL, Z., Cranial intrarelations and adaptability, 2nd Cong. Europ. Anthrop. Assoc. (Brno, 1980), in press.

ŠMAHEL, Z., Cephalometric and morphologic changes associated with unilateral cleft lip and palate in adults, *Acta Chir. Plast., 24:* 1–18, 1982.

VORA, J. M., and JOSHI, M. R., Mandibular growth in surgically repaired cleft lip and cleft palate individuals, *Angle Orthodont., 47:* 304–312, 1977.