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ROENTGEN-CEPHALOMETRIC ANALYSIS OF THE JAWS IN SUBJECTS WITH AND WITHOUT MANDIBULAR PROTRUSION

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INTRODUCTION

The use of cephalograms has proved to be very useful in determining the location and degree of various deformities of the jaws in order to be able to choose and plan adequate treatment.

Too little information is available concerning the limits of variation of the position of various anatomical landmarks within which the facial profile may have a »normal» appearance and the differences between men and women in this respect. There are also different opinions as to which distances and angles in cephalograms of patients with mandibular protrusion should be analysed.

The purpose of the present investigations was to measure and compare some distances and angles in cephalograms of adults with prognathic and »normal» facial profiles in order to discover which of these show statistically significant differences between prognathic and »normal» men and women. The results should provide the basis for the making of a useful and effective analysis chart for patients with a prognathic appearance including the average »normal» values for these measurements and their standard deviations.

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MATERIALS AND METHODS

In most cases, surgical correction of mandibular protrusion is performed when the patients are at the age of about 20. Therefore, 92 dental students and dental assistants ranging in age from 20 to 26 with »normal» facial appearance were selected to constitute the group of normal subjects. There were 48 women and 44 men, each of whom had a complete dentition with a »normal» relation between the maxilla and the mandible, *i. e.* normal values for the overjet and overbite.

The group of individuals with mandibular protrusion was comprised of all dentulous patients who had been referred to the Department of Orofacial prosthectics, School of Dentistry, University of Umeå, during the last few years for surgical correction of mandibular protrusion. The ages ranged from 18 to 35, the majority being 23 years of age. Of a total of 58 patients, 31 were women and 27 men.

Cephalograms of all subjects from the two groups were taken in a standardized manner in a cephalostat. The central ray was directed through the external auditory meatuses, perpendicular to the sagittal plane of the head and to the film. The focus-film distance was 155 cm and the distance between the film and the median plane of the head was 18 cm. The cephalograms were taken with the jaws related in the intercuspal position.

The following anatomical landmarks were identified on the cephalograms and marked with a pin hole (see Figs. 1 and 2).

1 – At this point the angle between the S-N line and the longitudinal axis of the most prominent upper incisor was measured.
2 — A, the upper apical base point.
3 — Incision superius, is, the midpoint of the contour of the incisal edge of the most prominent upper central incisor.
4 — Incision inferius, ii, the midpoint of the contour of the incisal edge of the most prominent lower central incisor.
5 — B, the lower apical base point.
6 — Pogonion, P, the point at which a line at right angle to the line between 7 and 9 passes through the most prominent point of the chin.
7 — Gnathion, Gn, the lowest point of the mandibular symphysis through which a tangent can be drawn to the lower margins of the corpus mandibulae.
8 — At this point the angle between the line 9—7 and the longitudinal axis of the most prominent lower incisor was measured.

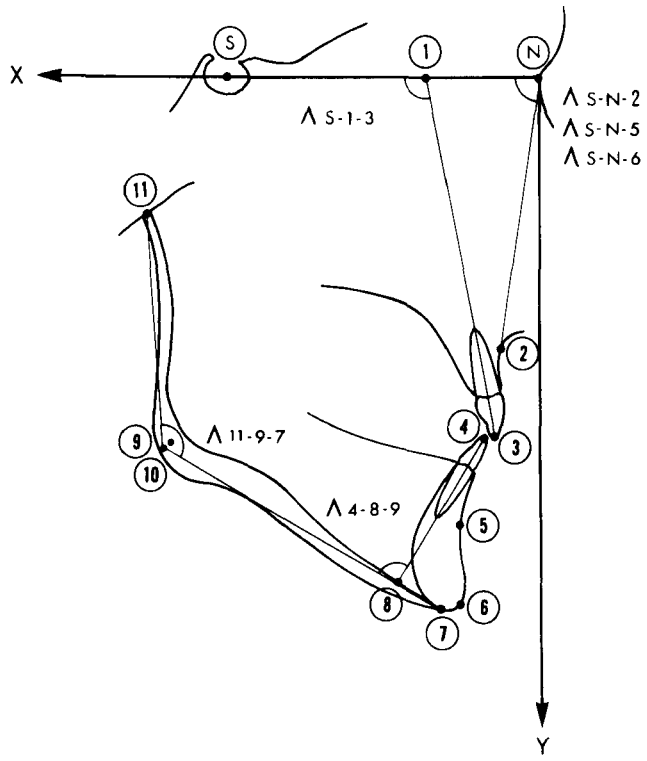

Fig. 1. Schematic tracing from a cephalogram showing points, angles, and distances analysed. »Normal» subjects.

9 — The intersection point of the two bisectors of the angles formed by the tangents to the posterior contours of the rami from Ar, 11, and by the tangents to the lower margins of the corpus from Gn, 7.

10 — Gonion, Go, the intersection point between the bisector of the gonial angle and the posterior contour of the mandible. If double contours half-way between them.

11 — Articulare, Ar, a point on the bone contour of the external cranial base half-way between the posterior margins of the rami mandibulae.

Through N (origo) perpendicular to the line S-N (the X axis) a line was drawn (the Y axis), see Figs. 1 and 2. These two lines constituted the basis for a coordinate system in which the various points were identified by their X and Y coordinate values.

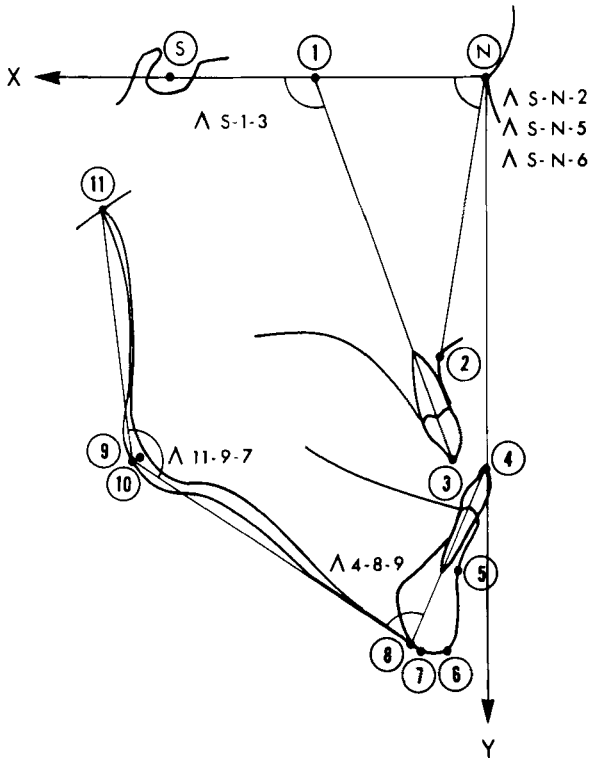

Fig. 2. Schematic tracing from cephalograms showing points, angles, and distances analysed. Subjects with mandibular protrusion.

All the measurements were performed directly on the cephalograms. One of the authors identified all the anatomical landmarks under study. The measurements were than performed by an assistant. The following distances and angles were measured:

Distances	Angles
S-N	Inclination of the upper incisors
P(6)-Go(10)	to the line between S and N,
Go(10)-Ar(11)	Inclination of the lower incisors
Go(10)-SN	to the line between 7 and 9,
ii(4)-Gn(7)	SNA,
	SNB,
	SNP,
	Angulus,
	SN to the mandibular line, ML.

All the values obtained were transferred to data processing cards which were processed in a CD 3200 computer.

RESULTS

The results of measurements on the cephalograms of the 92 »normal» men and women are tabulated in Tables I, II and III and presented diagramatically in Fig. 3.

In Figs. 5 and 6, a comparison between the normal subjects and the patients with mandibular protrusion is presented diagramatically.

There are statistically significant differences between »normal» men and women as can be observed in Tables I and III. Generally the height of the female face is shorter and the mandible smaller than corresponding distances

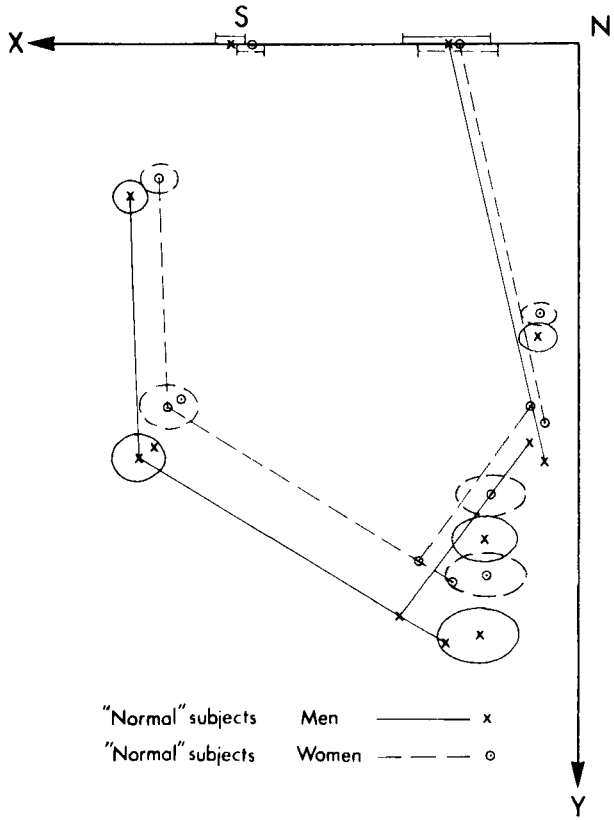

Fig. 3. The mean values and standard deviations for the coordinates of some points, *cf.* Fig. 1. »Normal» men and women.

Table 1

The X and Y coordinates of some anatomical landmarks in a coordinate system (Fig. 1) as measured on cephalograms of »normal» men and women, 20—26 years of age. Number of subjects = 92. The values are expressed in cm

Point		Men (44)		Women (48)		Diff.	Significance
		Mean	S.D.	Mean	S.D.		
1	X	2.9	0.95	2.6	0.86	0.3	
	Y	0		0		0	
2	X	0.9	0.43	0.9	0.38	0	
	Y	6.2	0.32	5.7	0.26	0.5	***
3	X	0.8	0.62	0.8	0.60	0	
	Y	8.8	0.38	8.0	0.36	0.8	***
4	X	1.1	0.60	1.1	0.58	0	
	Y	8.5	0.40	7.7	0.36	0.8	***
5	X	2.1	0.73	1.9	0.77	0.2	
	Y	10.5	0.51	9.6	0.42	0.9	***
6	X	2.2	0.89	2.0	0.88	0.2	
	Y	12.5	0.61	11.3	0.45	1.2	***
7	X	2.9	0.90	2.7	0.87	0.2	
	Y	12.7	0.55	11.4	0.41	1.3	***
8	X	3.9	0.88	3.5	0.96	0.4	*
	Y	12.1	0.51	11.0	0.40	1.1	***
9	X	9.6	0.61	8.9	0.65	0.7	***
	Y	8.7	0.53	7.7	0.48	1.0	***
10	X	9.2	0.59	8.7	0.61	0.5	***
	Y	8.5	0.50	7.5	0.44	1.0	***
11	X	9.7	0.37	9.1	0.42	0.6	***
	Y	3.2	0.33	2.9	0.31	0.3	***

Table II

Some anatomical angles (Fig. 1) as measured on cephalograms of »normal» men and women. The values are expressed in degrees

Angle	Men (44)		Women (48)		Diff.	Signifi-cance
	Mean	S.D.	Mean	S.D.		
Inclin. of upper inc. (SN-1—3)	103.3	7.01	102.9	8.78	0.4	—
Inclin. of lower inc. (4—8—9)	96.2	7.66	94.4	6.97	1.8	—
SNA (SN-2)	82.1	3.75	81.2	3.59	0.9	—
SNB (SN-5)	79.0	3.66	78.7	4.25	0.3	—
SNP (SN-6)	80.3	3.81	80.0	4.15	0.3	—
Angulus (11—9—7)	122.7	7.23	123.7	6.65	—1.0	—
SN-ML	30.7	6.40	31.2	5.75	—0.5	—

Table III

Some skeletal distances as measured on cephalograms of »normal» men and women. The values are expressed in cm. See Fig. 1 for identification of the anatomical landmarks

Distance	Men (44)		Women (48)		Diff.	Signifi-cance
	Mean	S.D.	Mean	S.D.		
S-N	7.6	0.32	7.1	0.30	0.5	***
Corpus (6—10)	8.2	0.44	7.7	0.44	0.5	***
Ramus (10—11)	5.4	0.41	4.7	0.43	0.7	***
Angulus perpendicular to SN (SN-10)	8.5	0.50	7.5	0.44	1.0	***
4—7	4.6	0.29	4.1	0.24	0.5	***

The corresponding results obtained for the 58 patients with mandibular protrusion are given in Tables IV, V and VI and in Fig. 4.

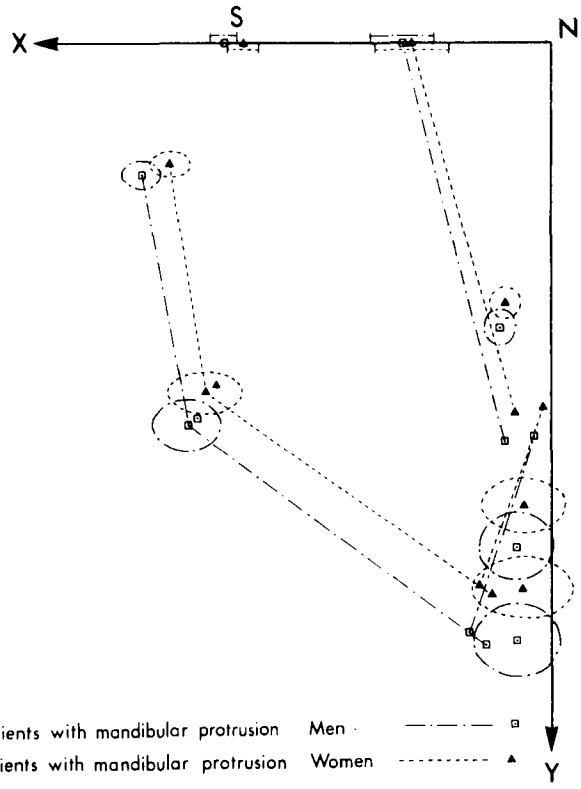

Fig. 4. The mean values and standard deviations for the coordinates of some points, *cf.* Fig. 2. Men and women with mandibular protrusion.

for men. The anterior points of the corpus mandibulae are, however, located in about the same plane in regard (4, 5, 6, 7, 8) to the Y axis as they are for men. This decrease of the lower face observed seem to be proportional since there were no statistically significant differences in the angles measured (Table II).

The corresponding values obtained for the 58 patients with mandibular protrusion are given in Tables IV, V and VI and in Fig. 4.

In general, the differences observed between men and women in the group of »normal» subjects were the same as those between the sexes in the group of patients with mandibular protrusion (*cf.* Figs. 3 and 4).

A comparison between »normal» men and men with mandibular protrusion is presented in Tables VII, IX and XI and in Fig. 5. There are significant differences between these two groups for all the angles measured in the man-

Table IV

As in Table I, but for patients with mandibular protrusion. See Fig. 2 for identification of the anatomical landmarks under study

Point		Men (27)		Women (31)		Diff.	Significance
		Mean	S.D.	Mean	S.D.		
1	X	3.4	0.73	3.1	0.84	0.3	—
	Y	0	—	0	—	0	—
2	X	1.1	0.36	1.0	0.34	0.1	—
	Y	6.3	0.42	5.8	0.33	0.5	***
3	X	1.0	0.52	0.8	0.60	0.2	—
	Y	8.9	0.40	8.2	0.48	0.7	***
4	X	0.4	0.58	0.2	0.73	0.2	—
	Y	8.8	0.62	8.1	0.59	0.7	***
5	X	0.8	0.83	0.6	0.95	0.2	—
	Y	11.2	0.77	10.3	0.62	0.9	***
6	X	0.8	0.98	0.7	1.15	0.1	—
	Y	13.3	0.82	12.2	0.74	1.1	***
7	X	1.5	1.03	1.3	1.18	0.2	—
	Y	13.4	0.78	12.3	0.68	1.1	***
8	X	1.8	1.07	1.6	1.20	0.2	—
	Y	13.2	0.74	12.1	0.66	1.1	***
9	X	8.3	0.79	7.9	0.87	0.4	—
	Y	8.5	0.58	7.8	0.48	0.7	***
10	X	8.1	0.76	7.7	0.82	0.4	*
	Y	8.4	0.55	7.7	0.47	0.7	***
11	X	9.3	0.45	8.7	0.46	0.6	***
	Y	2.9	0.31	2.7	0.29	0.2	**

Table V

As Table II, but for patients with mandibular protrusion. See Fig. 2 for identification of the angles listed

Angle	Men (27)		Women (31)		Diff.	Significance
	Mean	S.D.	Mean	S.D.		
Inclin. of upper inc. (SN-1—3)	104.6	5.71	105.8	8.25	—1.2	—
Inclin. of lower inc. (4—8 9)	72.0	7.49	74.8	9.05	—2.8	—
SNA (SN-2)	79.8	3.00	80.1	2.92	—0.3	—
SNB (SN-5)	86.1	4.01	86.7	5.13	—0.6	—
SNP (SN-6)	86.8	4.09	87.1	5.27	—0.3	—
Angulus (11—9—7)	136.0	7.05	133.6	6.94	2.4	—
SN-ML	35.7	6.59	34.5	5.93	1.2	—

Table VI

As Table III, but for patients with mandibular protrusion. See Fig. 2 for identification of the distances tabulated

Distance	Men (27)		Women (31)		Diff.	Significance
	Mean	S.D.	Mean	S.D.		
S-N	7.5	0.32	7.0	0.36	0.5	***
Corpus (6—10)	8.9	0.57	8.4	0.55	0.5	**
Ramus (10—11)	5.7	0.55	5.1	0.44	0.6	***
Angulus perpendicular to SN (SN-10)	8.4	0.55	7.7	0.47	0.7	***
4—7	4.8	0.34	4.4	0.27	0.4	***

Table VII

A comparison of some skeletal dimensions (Tables I and IV, left-hand columns) between »normal» men and men with mandibular protrusion

		Men					
Point		Mandibular protrusion (27)		Normal (44)		Diff.	Significance
		Mean	S.D.	Mean	S.D.		
1	X	3.4	0.73	2.9	0.95	0.5	*
	Y	0	—	0	—	0	—
2	X	1.1	0.36	0.9	0.43	0.2	*
	Y	6.3	0.42	6.2	0.32	0.1	—
3	X	1.0	0.52	0.8	0.62	0.2	—
	Y	8.9	0.40	8.8	0.38	0.1	—
4	X	0.4	0.58	1.1	0.60	—0.7	***
	Y	8.8	0.62	8.5	0.40	0.3	*
5	X	0.8	0.83	2.1	0.73	—1.3	***
	Y	11.2	0.77	10.5	0.51	0.7	***
6	X	0.8	0.98	2.1	0.89	—1.3	***
	Y	13.3	0.82	12.5	0.61	0.8	***
7	X	1.5	1.03	2.9	0.90	1.4	***
	Y	13.4	0.78	12.7	0.55	0.7	***
8	X	1.8	1.07	3.9	0.88	—2.1	***
	Y	13.2	0.74	12.1	0.51	1.1	***
9	X	8.3	0.79	9.6	0.61	1.3	***
	Y	8.5	0.58	8.7	0.53	—0.2	
10	X	8.1	0.76	9.2	0.59	—1.1	***
	Y	8.4	0.55	8.5	0.50	—0.1	—
11	X	9.3	0.45	9.7	0.37	—0.4	***
	Y	2.9	0.31	3.2	0.33	0.3	***

Table VIII

A comparison of some skeletal dimensions (Tables I and IV, right-hand columns) between »normal» women and women with mandibular protrusion

		Women					
Point		Mandibular protrusion (31)		Normal (48)		Diff.	Significance
		Mean	S.D.	Mean	S.D.		
1	X	3.1	0.84	2.6	0.86	0.5	*
	Y	0	—	0	—	0	—
2	X	1.0	0.34	0.9	0.38	0.1	—
	Y	5.8	0.33	5.7	0.26	0.1	—
3	X	0.8	0.60	0.8	0.60	0	—
	Y	8.2	0.48	8.0	0.36	0.2	*
4	X	0.2	0.73	1.1	0.58	—0.9	***
	Y	8.1	0.59	7.7	0.36	0.4	***
5	X	0.6	0.95	1.9	0.77	—1.3	***
	Y	10.3	0.62	9.6	0.42	0.7	***
6	X	0.7	1.15	2.0	0.88	—1.3	***
	Y	12.2	0.74	11.3	0.45	0.9	***
7	X	1.3	1.18	2.7	0.87	—1.4	***
	Y	12.3	0.68	11.4	0.41	0.9	***
8	X	1.6	1.20	3.5	0.96	—1.9	***
	Y	12.1	0.66	11.0	0.40	1.1	***
9	X	7.9	0.87	8.9	0.65	—1.0	***
	Y	7.8	0.48	7.7	0.48	0.1	—
10	X	7.7	0.82	8.6	0.61	—0.9	***
	Y	7.7	0.47	7.5	0.44	0.2	—
11	X	8.7	0.46	9.1	0.42	—0.4	***
	Y	2.7	0.29	2.9	0.31	0.2	*

Table IX

A comparison of some skeletal angles (Tables II and V, left-hand columns) between »normal» men and men with mandibular protrusion

Angle	Men				Diff.	Significance
	Mandibular protrusion (27)		Normal (44)			
	Mean	S.D.	Mean	S.D.		
(SN-1—3)	104.6	5.71	103.3	7.01	1.3	—
(4—8—9)	72.0	7.49	96.2	7.66	—24.2	***
SNA (SN-2)	79.8	3.00	82.1	3.76	— 2.3	*
SNB (SN-5)	86.1	4.01	79.0	3.66	7.1	***
SNP (SN-6)	86.8	4.09	80.3	3.81	6.5	***
Angulus (11—9—7)	136.0	7.05	122.7	7.23	13.3	***
SN-ML	35.7	6.59	30.7	6.40	5.0	**

Table X

A comparison of some skeletal angles (Tables II and V, right-hand columns) between »normal» women and women with mandibular protrusion

Angle	Women				Diff.	Significance
	Mandibular protrusion (31)		Normal (48)			
	Mean	S.D.	Mean	S.D.		
(SN-1—3)	105.8	8.25	102.9	8.78	2.9	—
(4—8—9)	74.8	9.05	94.4	6.97	—19.6	***
SNA (SN-2)	80.1	2.92	81.2	3.59	— 1.1	—
SNB (SN-5)	86.7	5.13	78.7	4.25	8.0	***
SNP (SN-6)	87.1	5.27	80.0	4.15	7.1	***
Angulus (11—9—7)	133.6	6.94	123.7	6.65	9.9	***
SN-ML	34.5	5.93	31.2	5.75	3.3	*

Table XI

A comparison of some skeletal distances (Tables III and VI, left-hand columns) between »normal» men and men with mandibular protrusion

Men						
Distance	Mandibular protrusion (27)		Normal (44)		Diff.	Significance
	Mean	S.D.	Mean	S.D.		
S-N	7.5	0.32	7.6	0.32	0.1	–
Corpus (6—10)	8.9	0.57	8.2	0.44	0.7	***
Ramus (10—11)	5.7	0.55	5.4	0.41	0.3	*
Angulus perpendicular to SN (SN-10)	8.4	0.55	8.5	0.50	—0.1	—
4—7	4.8	0.34	4.6	0.29	0.2	**

Table XII

A comparison of some skeletal distances (Tables III and VI, right-hand columns) between »normal» women and women with mandibular protrusion

Women						
Distance	Mandibular protrusion (31)		Normal (48)		Diff.	Significance
	Mean	S.D.	Mean	S.D.		
S-N	7.0	0.36	7.1	0.30	0.1	—
Corpus (6—10)	8.4	0.55	7.7	0.44	0.7	***
Ramus (10—11)	5.1	0.44	4.7	0.43	0.4	***
Angulus perpendicular to SN (SN-10)	7.7	0.47	7.5	0.44	0.2	—
7—4	4.4	0.27	4.1	0.24	0.3	***

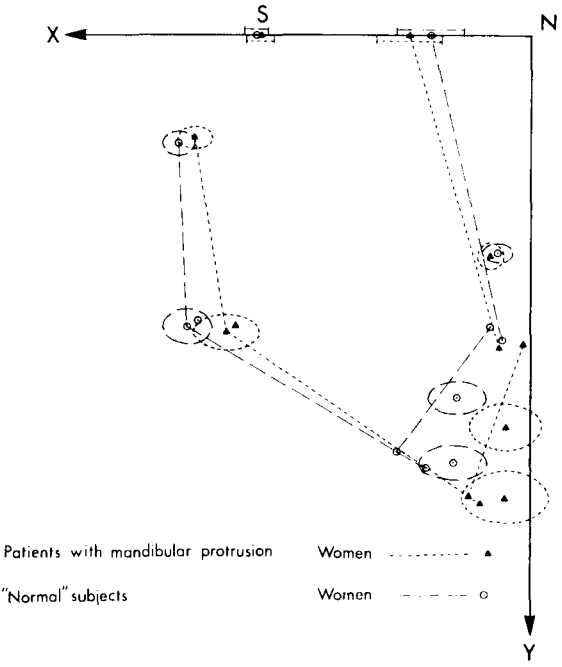

Fig. 5. The mean values and standard deviations for the coordinates of some points. »Normal» men and men with mandibular protrusion.

dible, while no such differences exist with respeet to the maxillary angles. There are also significant differences in the mandibular length and the mental height (the distances 6—10 and 4—7 respectively) while the length of the ramus (distance 10—11) is not significantly different. Significant differences in the height of the face (N-7) were found between »normal» and protrusive individuals of both sexes. Calculations showed that this difference can be referred to the mental height (4—7).

The results of the comparisons of these angles and distances in »normal» women and women with mandibular protrusion (*cf.* Tables VIII, X and XII and in Fig. 6) were the same as those for men with the main exception of the length of the ramus, where statistically significant differences were observed.

DISCUSSION

The various types of errors in measurements on cephalograms have been studied and discussed extensively in the literature (*e.g. Björk*, 1947; *Moor-*

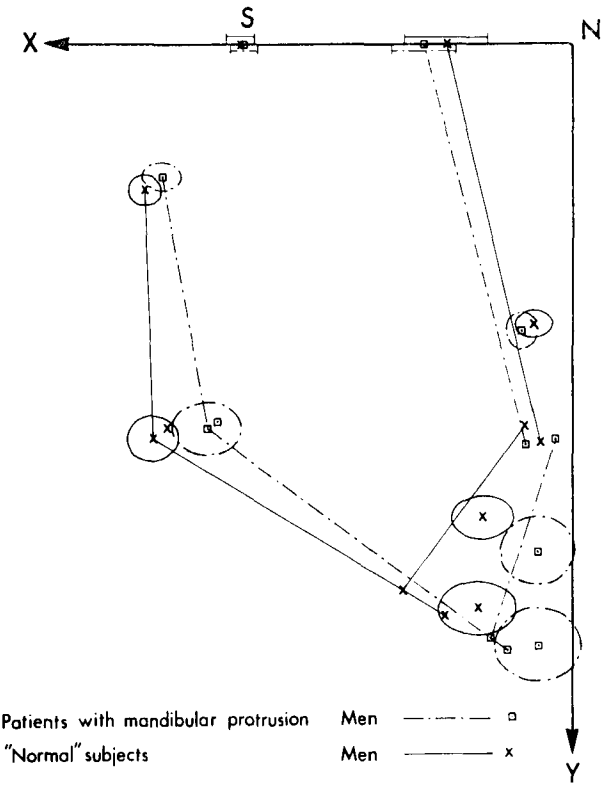

Fig. 6. The mean values and standard deviations for the coordinates of some points. »Normal» women and women with mandibular protrusion.

rees, 1953; *Moorrees & Kean*, 1958; *Sarnäs*, 1959; *Hollender*, 1964; *Savara, Tracy & Miller*, 1966; *Carlsson*, 1967).

The group of »normal» subjects was not randomly compiled. To choose only subjects with so-called anatomical correct occlusion in all respects seemed for the present investigation and comparison to be unnecessarily strict. It should have been very time-consuming to find a sufficiently large group with anatomical correct occlusion (*Werner*, 1954). Furthermore, the prognathic patients will after treatment not have such an ideal occlusion. The »normal» subjects were selected on the basis of a normal harmonious profile, face and dental relations (*Margolis*, 1947).

The technique of using a coordinate system was introduced at the beginning of the sexteenth century by Albert Dürer; similar methods have been used by *de Coster* (1939), *Thompson* (1942), *Moorrees* (1953) and many others. Using

a coordinate system has proved to be very useful in measurements of this type.

The results obtained for the »normal» men and women are in agreement with previously published data, wherever it is possible to compare (*e.g. Björk*, 1947; *Iyer*, 1953; *Lindegård*, 1953; *Moorrees*, 1953; *Werner*, 1954; *Steiner*, 1959; *Hogeman et al.*, 1967).

The statistically significant differences observed between men and women indicate that separate mean values for »normal» men and women must be used in the analysis of the nature and extent of mandibular protrusion.

The results also show that all of the differences observed between the groups of »normal» and protrusive individuals occurred in the mandible.

No significant differences in the inclination of the upper incisors were observed. On the other hand, the lower incisors in the patients with mandibular protrusion showed a larger angle to the mandibular base line (Angle 4—8—9) than did those in the normal subjects. Thus, proclination of the mandibular incisors seems to be associated with the occurrence of mandibular protrusion while the anterior part of the maxilla and its incisors are not involved in general.

SUMMARY

Cephalometric measurements have been made on 92 »normal» subjects, 44 men and 48 women, and on 58 subjects, 27 men and 31 women, with mandibular protrusion. Statistically significant differences were observed between men and women in both groups with respect to the distances measured. However, there were no differences in the angles. The differences appeared mainly in the mandible.

In a comparison between men and men and women and women respectively in the two groups, significant differences were found principally in the mandible. The differences were observed for the distances as well as for the angles measured.

On the basis of these observations a scheme for preoperative, cephalometric analysis has been presented for clinical use.

RÉSUMÉ

ANALYSE RADIOCÉPHALOMÉTRIQUE DES MÂCHOIRES CHEZ DES SUJETS AVEC ET SANS PROGNATHIE MANDIBULAIRE

Des mensurations céphalométriques ont été effectuées chez 92 sujets »normaux», dont 44 hommes et 48 femmes, et chez 58 sujets, dont 27 hommes et

31 femmes, présentant une prognathie mandibulaire. Des différences statistiquement significatives ont été observées entre les hommes et les femmes dans les deux groupes en ce qui concernait les mesures des distances. Il n'existait par contre pas de différences entre les angles. Les différences étaient principalement observées au niveau de la mandibule.

Une comparaison entre les hommes des deux groupes et entre les femmes des deux groupes a mis en évidence des différences significatives, principalement au niveau de la mandibule. Les différences observées concernaient les mesures des distances ainsi que celles des angles.

Se basant sur ces observations, les auteurs présentent un plan à suivre en clinique pour l'analyse céphalométrique pré-opératoire.

ZUSAMMENFASSUNG

RÖNTGENKEFALOMETRISCHE BEURTEILUNGEN DER KIEFER BEI PATIENTEN MIT UND OHNE MANDIBULÄRER PROTRUSION

Röntgenkefalometrische Beurteilungen sind auf 92 sog. normale Patienten ausgeführt worden, 44 Männer och 48 Frauen; und auf 58 Patienten, 27 Männer und 31 Frauen, mit mandibulärer Protrusion. In Hinsicht auf die aufgemessenen Strecken sind signifikante Unterschiede zwischen Männern und Frauen der beiden Gruppen bemerkt worden. Abweichungen in Winkelmassen waren aber nicht festzustellen.

Die Unterschiede waren hauptsächlich im Unterkiefer zu sehen. Im Vergleich Männer/Männer und Frauen/Frauen der zwei Gruppen sind signifikante Unterschiede vorwiegend im Unterkiefer entdeckt worden. Diese sind sowohl mit Längenmassen als auch mit Winkelmassen beobachtet worden.

Auf Grund dieser Ergebnisse ist ein Plan für preoperative kefalometrische Beurteilung vorgestellt worden. Dieser Plan ist für klinischen Gebrauch geeignet.

REFERENCES

Björk, A., 1947: The face in profile. Svensk tandläk.-T., *40:* Suppl.: 5 B.

Carlsson, G. E., 1967: Errors in x-ray cephalometry. Odont. T., *75:* 2.

de Coster, L., 1939: The network method of orthodontic diagnosis. Angle Orthodont., *9:* 3.

Hogeman, K.-E., K.-Å. Omnell, K.-V. Sarnäs, & K. Willmar, 1967: Surgical and dental-orthopaedic correction of horizontal and vertical malocclusions. Scand. J. Plast. reconstr. Surg. *1:* 45.

Hollender, L., 1964: Determining the elements of the interior orientation in roentgenography. Acta radiol. (Stockh.) 230.

Iyer, V. S., 1953: Utility of the maxillofacial triangel in orthodontic diagnosis. Dent. Rec., *73:* 316.

Lindegård, B., 1953: Variations in human body-build. Acta psychiatr. (Kbh), Suppl. 86.

Margolis, H. I., 1947: A basic facial pattern and its application in clinical orthodontics. Amer. J. Orthodont., *33:* 631.

Moorrees, C. F. A., 1953: Normal variation and its bearing on the use of cephalometric radiographs in orthodontic diagnosis. Amer. J. Orthodont., *39:* 942.

Morrees, C. F. A. & M. R. Kean, 1958: Natural head position, a basic consideration in the interpretation of cephalometric radiographs. Amer. J. phys. Anthrop., *16:* 213.

Sarnäs, K. V., 1959: Inter- and intra-family variations in the facial profile. Odont. Revy, *10:* Suppl. 4.

Savara, B. S., W. E. Tracy & P. A. Miller, 1966: Analysis of errors in cephalometric measurements in three-dimensional distances on the human mandible. Arch. oral Biol., *11:* 209.

Steiner, C. C., 1959: Cephalometrics in clinical practice. Angel Orthodont., *29:* 8.

Thompson, D. W., 1942: On growth and form. Cambridge University Press, Cambridge, England.

Werner, H., 1954: Bestämning av överkäkens och underkäkens cefalometriska orientering. Svensk tandläk.-T., *47:* 419.

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