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POSITIONAL CHANGES OF THE MANDIBLE AFTER SURGICAL CORRECTION OF MANDIBULAR PROTRUSION BY HORIZONTAL OSTEOTOMY OF THE RAMI

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INTRODUCTION

Postoperative changes in the positions of the mandible and the upper fragments after bilateral osteotomy of the ramus mandibulae in the treatment of mandibular protrusion have been reported (*e.g. Gelkermann*, 1935; *Wassmund*, 1935; *Lindemann*, 1936; *Kazanjian*, 1932, 1936, 1941; *Thourén*, 1935, 1945; *Bruhn*, 1939; *Hogeman*, 1951; *Lysell, Nyquist & Öberg* 1960; *Fromm, Nordh & Nordström*, 1962 *cf.* also the review by *Hogeman*, 1951 p. 32). Already *Babcock* (1909), the originator of the bilateral horizontal osteotomy of the ramus mandibulae, noticed that »the chief difficulty in the after-treatment is the tendency of the chin to drop». However, very few systematic follow-up examinations have been published. The positional changes which have been reported are mainly restricted to a forward-upward movement of the upper fragments and a forward-downward movement of the mandible resulting in a recidivation tendency and an open bite anteriorly.

The purpose of the present investigation was to study the magnitude and direction of the positional changes of the mandible after surgical correction of mandibular protrusion.

Bilateral horizontal osteotomy of the ramus was used. The patient material (Fig. 1) was divided into two groups:

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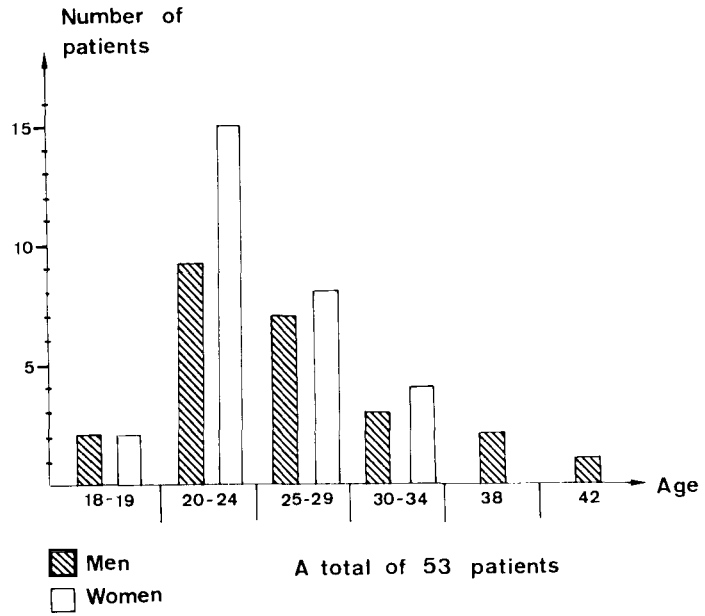

Fig. 1. The age and sex of the patients analyzed in this study and treated for mandibular protrusion by horizontal osteotomy of the rami and intermaxillary fixation by means of cap-splints.

A. Patients operated by external approach according to *Babcock*.
B. Patients operated by intraoral approach according to *Stenström*.

A. PATIENTS OPERATED AD MODUM BABCOCK

MATERIAL AND METHODS

Of the patients referred to the School of Dentistry at Umeå University for surgical correction of mandibular protrusion (Angle Class III cases) during the period 1958—1966, forty-five were included in the present investigation. Only those patients who had been operated *ad modum* Babcock and in whom cap-splints had been used for intermaxillary fixation were considered.

A bilateral horizontal osteotomy of the ramus mandibulae was performed between lingula and incisura mandibulae (notch) through an extraoral approach and a retroposition of the mandible into a predetermined position. Intermaxillary fixation by cap-splints cemented on the teeth was maintained for a period of nine or ten weeks of consolidation.

Cephalometric roentgenograms for analysis of postoperative movements of the mandible were taken in a cephalostat with a straight lateral projection. The central ray was directed through the external meatuses and 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. Cephalograms were taken in intercuspal position at the following time intervals:

2—3 weeks before operation, referred to in this study as *occasion 1*

1 week after operation, referred to in this study as *occasion 2*

9 weeks after operation, referred to in this study as *occasion 3*

½ year after operation, referred to in this study as *occasion 4*

1—1 ½ year after operation, referred to in this study as *occasion 5*

2 ½ years after operation, referred to in this study *as occasion 6*

For some patients, one or two cephalograms were missing. Therefore, in Table I and in Figs. 4 and 5 the various values given are not in all cases based on exactly forty-five patients.

The following anatomical landmarks were identified on the cephalograms and labelled with a needle hole to be used in the cephalometric analysis (see Fig. 2):

Sella (S) — the centre of the sella turcica.

Nasion (N) — the most anterior point of the frontonasal suture.

Gnathion (I) — The lowest point of the mandibular symphysis.

Gonion (II) — the lowest point of the mandible in the angular area to which a tangent could be drawn from the gnathion; in cases of double contours of the lower borders in the cephalograms, the point (II) was identified as half the distance on the line between the corresponding points of the right and left side of the mandible (see Fig. 2). The distance between I and II obtained on the preoperative cephalogram was then used for identification of point II on all the subsequent postoperative cephalograms.

Articulare (III) — the intersection between the bone contour of the external cranial base and the posterior contour of the condyle process.

All the measurements were performed directly on the cephalograms. Tracings of the posterior border of the ramus and the lower border of the corpus were made on semi-transparent paper from the cephalograms. One of the investigators made all the identifications of the anatomical landmarks under discussion and performed all measurements and tracings.

On each cephalogram the points I, II and III were recorded as coordinates in a coordinate system with the line S-N as abscissa and the point N as origo. The coordinates were measured with a millimetre grid (Aristo 4830) to the nearest half millimetre.

Errors in the cephalographic analysis have been studied and discussed by *Lysell, Nyquist & Öberg* (1960) and *Carlsson* (1967).

All the values obtained were transferred to data processing cards which were treated in an IBM 1620 computer system with an IBM 1627 plotting machine.

RESULTS

The mean values and standard deviations of the coordinates (X and Y) for the points I, II and III (*cf.* Fig. 2) at the various examinations (occasions 1—6) for roentgen cephalometry are listed in Table I.

The mean value for the distance of the retroposition of the mandible at the operation was 13.5 mm for point I and 13.0 mm for point II, an almost parallel recession, as can be seen in Fig. 4.

During the period of intermaxillary fixation (occasions 2—3) point I moved about 4 mm and point II about 7 mm. The postfixational movements of the angulus, point II, (occasions 4—6) were less than 5 mm. In half the cases a postfixational lengthening of the rami was observed. After 1—1 ½ years the mandible seemed to have reached a stable position. The actual two-dimensional movements of the line between the points I and II for some patients are graphically represented in Fig. 3 as plotted by the computer. In Fig. 4 the mean values are presented for the various occasions. The positions of the points I and II at the 6 occasions can also be seen in Fig. 5.

As can be seen in Table I and in Figs. 3, 4 and 5 there are pronounced movements of the mandible during the intermaxillary fixation period (occasions 2—3). The directions of the movements of points I and II are graphically recorded in Fig. 5, where the mean values of X and Y coordinates have

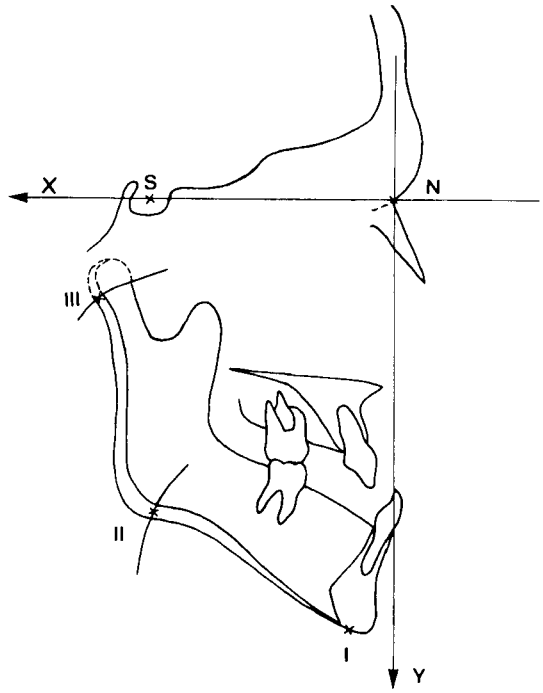

Fig. 2. Schematic tracing from a cephalogram showing the three points analyzed. Point I — gnathion, point II — gonion and point III — articulare.

Table I.

Mean values (M) and corresponding standard deviations (S.D.) for the coordinates (X and Y) of the points I, II, III (Fig. 2.) before (1) and at various postoperative periods (2—6). The values are expressed in mm and indicate the distances from the points Gn (I), Go (II) and Ar (III) to the line S-N (the Y coordinate) and to the line through N perpendicular to S-N (the X coordinate)

Occasion	Point I		Point II		Point III	
	X	Y	X	Y	X	Y
1 M	12.7	128.4	71.7	85.5	88.6	28.4
S.D.	15	14	12	10	8	5
2 M	26.2	129.7	84.7	84.4	89.8	28.4
S.D.	22	20	15	17	12	6
3 M	29.2	128.8	81.3	78.8	86.8	28.0
S.D.	18	15	13	13	10	5
4 M	26.6	129.0	80.4	79.5	88.5	28.8
S.D.	22	17	15	17	10	7
5 M	25.3	127.3	79.1	78.7	87.8	27.7
S.D.	15	14	11	13	9	5
6 M	25.4	127.1	79.7	78.9	88.2	28.0
S.D.	18	15	13	14	9	6

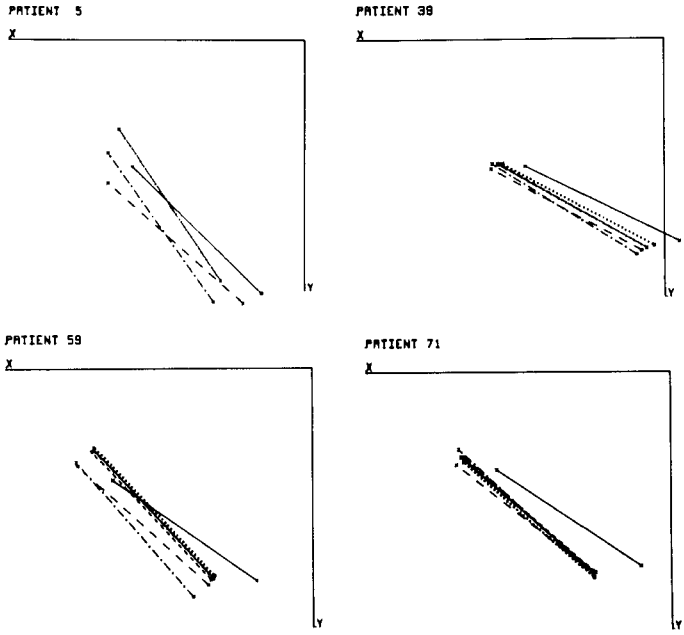

Fig. 3. Computer recordings of the position of the line between point I and point II before and at various times after operation for four patients. The key to the lines is presented in Fig. 4.

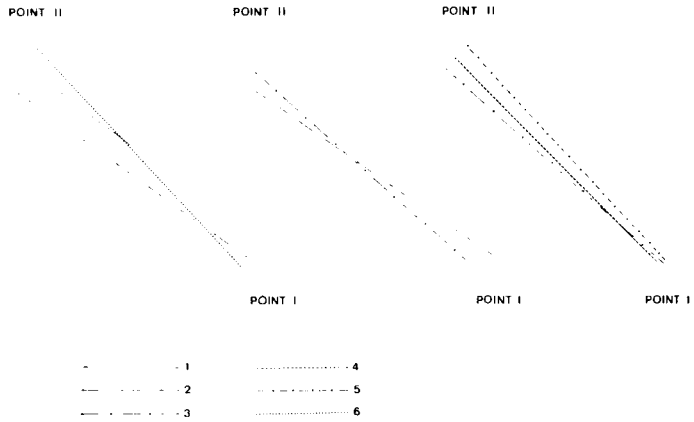

Fig. 4. The positions of the lower border of corpus mandibulae (points I and II) before operation (1) and at various times postoperatively (2—6). The dotted line (6) thus indicates the final position of corpus mandibulae. The mean values of the coordinates X and Y in respect to the S-N line (X) and a line perpendicular to S-N through N (Y) are given (*cf.* Table 1). The left diagram shows the positions at the three occasions 1, 2, and 6, in the middle 2 and 3, and to the right 3, 4, and 5.

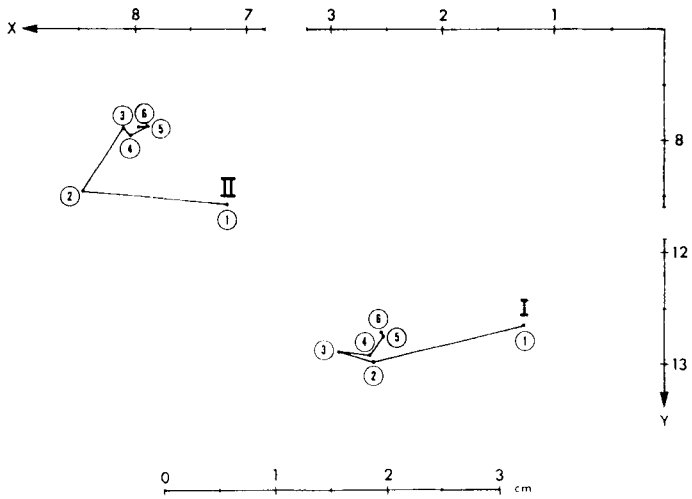

Fig. 5. The mean of the positions of the points I and II at the various times of analysis (occasions 1–6).

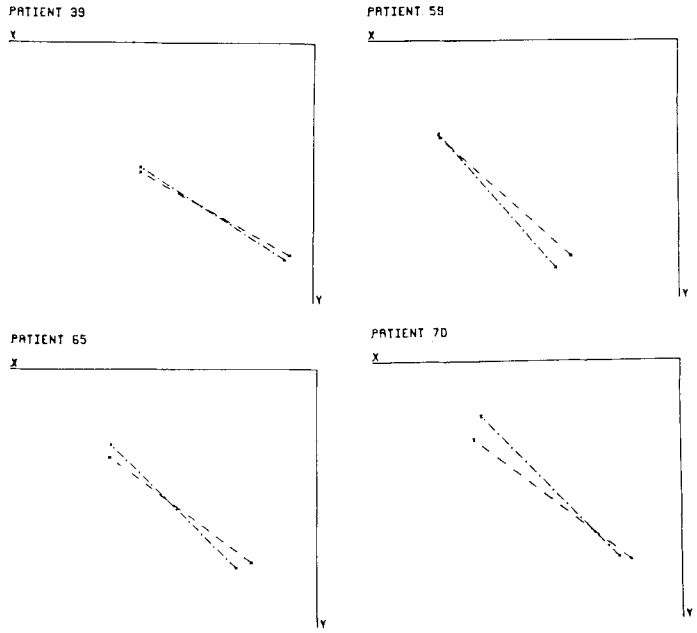

Fig. 6. Computer recordings of the position of the line between point I and point II at one week after (2) and at nine weeks after the operation (3), i.e. the positional changes of the mandible during the period of intermaxillary fixation. The key to the lines is presented in Fig. 4.

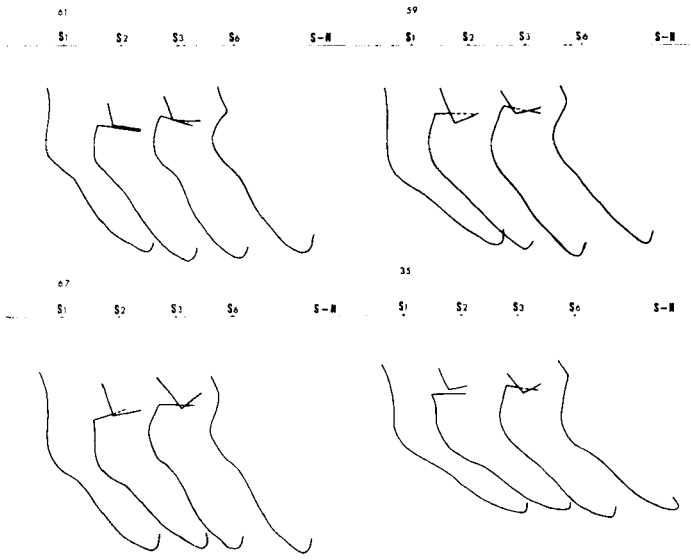

Fig. 7. Tracings of the posterior contour of the ramus and the lower border of the corpus before (1) and at one week (2), nine weeks (3) and 2 ½ years (6) after the operation. S indicates the position of the centre of the sella turcica.

been plotted. The movement is a rotation through an axis located between the two points I and II. The location of this rotation axis varies considerably from case to case, from the vicinity of the point I to a region close to point II, as can be seen in Fig. 6. In general, the angle between the lines S-N and Go-Gn increased 6°.

The movements of point III (articulare, at the posterior border of the upper fragments) can be seen in Table I. During the immobilization period (occasions 2—3) this point moved about 3 mm in an anterior direction, which indicated that this fragment rotated during this period. Subsequent cephalograms did not show any significant positional changes of this point.

Tracings of the posterior contour of the ramus and the lower border of the corpus representing occasions 1, 2, 3 and 6 are compiled for a randomly selected sample of the patients in Fig. 7. The rotation of the upper fragment found in Table I was confirmed in the tracings. Where this fragment overlapped the ramus in the osteotomy region, roentgenograms obtained by posterior-anterior projections revealed that the upper fragments in all cases were located lateral to the lower fragment.

After complete consolidation, the posterior border of the ramus was curved in most cases.

DISCUSSION

In the present study, stabilization of the mandible in its new position seems to occur 1—1 ½ years postoperatively.

Definite positional changes of the mandible and of the upper fragments occurred after operation. The most pronounced changes were seen during the intermaxillary fixation period.

Obviously, the muscle activities caused the postoperative positional changes observed. The movements of the three fragments were mainly rotational in nature. The rotation of the large mandibular fragment occurred in spite of the fact that all the patients were orally immobilized by means of cap-splints. Stretching of the intermaxillary stainless steel ligatures, minor deformation of the splints, and extrusion of the anterior teeth as observed by *Lundberg* and *Öberg* (1957) admitted the rotation of the lower fragment.

The rotation axis of the mandible varied considerably. It seems probable that the position of this axis is determined by the number of posterior teeth: the fewer posterior teeth the further forward was the rotation axis located.

It is of interest to note that gonion moved, on an average 6 mm, almost exclusively in an upward direction, while gnathion moved, on an average 3 mm, in a backward direction. There was a considerable shortening of the rami during the fixation period. This observation is in agreement with those of *Lysell et al.* (1960); *Fromm et al.* (1962).

The observed rotation of the upper fragment, which occurred almost exclusively during the fixation period, is in agreement with previous reports. *Hogeman* (1951) noted that this fragment rotated 15° and *Lysell et al.* (1960) reported 14.1°. In spite of this rotation, the movement capacity of the jaw has not been found to be unfavourably influenced (*Lundberg*, 1964).

It has to be borne in mind when evaluating the movements occurring between the occasions 3 and 4 that cap-splints were *in situ* at occasion 3 but not at occasion 4 and that occlusal grinding was in general done immediately after the removal of the cap-splints.

After the termination of the intermaxillary fixation (nine or ten weeks postoperatively) only minor movements of the mandible were noted. These postfixation movements are probably mainly due to grinding of the teeth in order to re-establish good occlusion by eliminating a frontal open bite. Prosthetic restorations may also cause movements of the mandible and may explain the postfixation lengthening of the rami observed in some cases.

No evident increase of the face height could be noted.

It can be concluded from this long term study that a number of undesirable

movements occur, especially during the fixation period. Fixation methods more stable than cap-splints are not available at present. Metal ligatures for the intermaxillary fixation should be avoided, rigid cast locks cemented or screwed to the upper and lower cap-splints will keep the cap-splints in a fixed occlusion more satisfactorily.

B. PATIENTS OPERATED AD MODUM STENSTRÖM

An attempt was made to get contacts between the fragments in order to be able to reduce the fixation period by trying to prevent undesirable postoperative positional period (rotation) of the fragments observed and described in section A.

MATERIAL AND METHODS

In cooperation with Dr. Sten Stenström, Head of the Department of Plastic Surgery at the University of Umeå, the fragments were fixed together with one or two transosseous wires of stainless steel in the anterior region of the ramus. For this purpose a new surgical method and some new instruments were developed by Dr. Stenström. Through an intraoral approach the ascending rami of the mandible between the notch and lingula were dissected free on both sides.

The bilateral horizontal osteotomy were performed by using a Gigli saw in connection with some special guiding devices. After retroposition of the mandible into the predetermined position the upper fragments were fixed to the lower one by means of osteosutures immediately after the intermaxillary fixation by cap-splints was made.

Postoperative treatments, clinical observations and cephalometric analyses were made on the eight patients in accordance with the techniques described in section A. Cap-splints with cast locks were used for a stable intermaxillary fixation. The observation periods were also the same as in section A. Eight patients, 4 men and 4 women, were treated by this method.

Operative experiences were first gained on human cadavers and on a few patients not included in this series.

RESULTS

The results obtained for these patients are tabulated in Table II and graphically visualized in Fig. 8. As can be seen there were pronounced positional

Table II.

As in Table I, i.e. mean values (M) and corresponding standard deviations (S.D.) for the coordinates (X and Y) of the points I, II, III (Fig. 2) before (1) and at various post-operative periods (2—6). The values are expressed in mm and indicate the distances from the points Gn (1), Go (II) and Ar (III) to the line S-N (the Y coordinate) and to the line through N perpendicular to S-N (the X coordinate). The patients operated ad modum Stenström

Occasion	Point I		Point II		Point III	
	X	Y	X	Y	X	Y
1 M	17.8	129.8	76.3	85.4	90.3	27.8
S.D.	11.5	10.6	8.2	6.9	6.3	3.0
2 M	27.2	128.4	87.1	85.2	90.1	27.3
S.D.	7.4	6.6	6.9	7.1	6.0	3.1
3 M	32.7	130.0	86.7	80.0	89.9	27.8
S.D.	7.7	9.5	7.2	9.9	6.8	3.6
4 M	33.8	130.4	84.8	77.4	89.9	27.4
S.D.	9.7	10.1	8.2	10.0	5.2	3.4
5 M	32.6	128.8	81.6	74.0	86.5	27.6
S.D.	8.7	6.5	5.1	6.2	5.3	2.9
6 M	32.2	128.9	81.6	74.3	87.0	27.6
S.D.	8.4	6.8	5.1	6.1	5.8	2.8

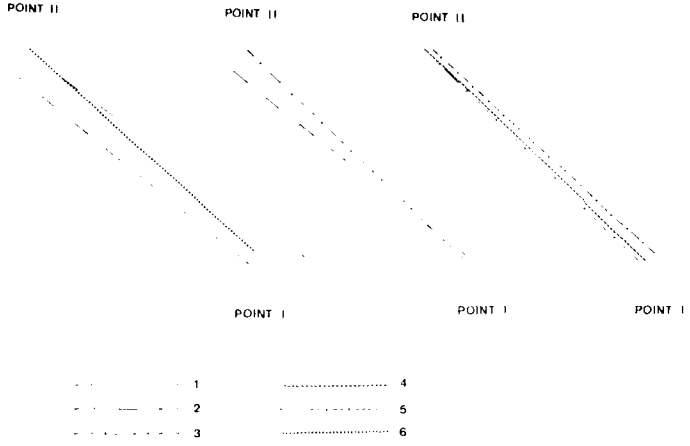

Fig. 8. Graphical recordings of the points I and II as in Fig. 4 for the eight patients operated *ad modum* Stenström (*cf.* Table 2).

changes of the three points also in these patients in spite of the internal wiring fixation of the fragments. On the cephalograms it was observed that the holes for the stainless steel wires became more and more oval. It was also observed that the wires became very much stretched; in one case to such an extent that the wires on both sides broke about 4 weeks after operation.

DISCUSSION

The positional changes observed in this group were mainly of the same magnitude and direction as in group A, although the rotation of the upper fragments were somewhat less.

Due to these changes the period of intermaxillary fixation was not reduced. Evidently the muscle activity renders it difficult to keep the fragments in position. It is notable that in these patients the metal intermaxillary ligatures were exchanged to cast locks, which gave a very stable and rigid intermaxillary fixation. Thus, this method did not give better results than the other horizontal osteotomy methods described in section A. Furthermore, this method is technically difficult and time consuming and the postoperative discomfort for the patients seemed to be more serious than after operations according to Babcock's method. Since none of the expected advantages with this method were obtained, there were no reasons to proceed using Stenström's method and the number of patients in this series is consequently small.

SUMMARY

A follow-up study with roentgen cephalometry was performed during a 2 1/2 year post-operative period on fifty-three patients, who had been treated for mandibular protrusion by the Babcock surgical method (45 patients) and by Stenström's intraoral surgical method (8 patients) and intermaxillary fixation by means of cap-splints.

Considerable movements of the mandible and the upper fragments were found. The positional changes of the fragments as well as the mandible were most pronounced during the period of fixation. The movements were principally rotational in nature.

After the fixation period, minor positional changes of the mandibular fragments were observed long as 1—1 ½ years post-operatively. From this time to 2 ½ years, no significant changes were found. The upper fragments seem to stabilize in their final positions approximately nine weeks after the operation.

No main differences of the positional changes between the two groups of patients were observed.

Possible explanations for these movements, which are primarily rotational, have been discussed.

RÉSUMÉ

CHANGEMENTS DE POSITION DE LA MANDIBULE APRÈS CORRECTION CHIRURGICALE DE LA PROGNATHIE MANDIBULAIRE PAR OSTÉOTOMIE HORIZONTALE DES BRANCHES MONTANTES

Une étude par céphalométrie avec contrôle suivi a été effectuée sur une période post-opératoire de 2 ans ½ chez 53 patients traités pour une prognathie mandibulaire, par la méthode chirurgicale de Babcock (45 patients) et par la méthode chirurgicale intra-orale de Stenström (8 patients), avec contention intermaxillaire par gouttières oculées.

Des mouvements considérables de la mandibule et des fragments supérieurs ont été mis en évidence. Les changements les plus importants dans la position des fragments et dans la position de la mandibule se produisaient pendant la période de contention. Les mouvements observés étaient principalement des mouvements de rotation.

Après la période de contention, on observait de petits changements de la position des fragments mandibulaires jusqu'à 1—1 an ½ après l'opération. Ensuite, et jusqu'à 2 ans ½, on ne notait pas de changements significatifs. Les fragments supérieurs semblaient se stabiliser dans leur position définitive environ 9 semaines après l'opération.

Il n'a pas été observé de différences fondamentales entre les changements de position ayant lieu dans les deux groupes de patients considérés.

Les explications possibles de ces mouvements, qui sont principalement des mouvements de rotation, ont fait l'objet d'une discussion.

ZUSAMMENFASSUNG

LAGEVERÄNDERUNGEN DES UNTERKIEFERS NACH OPERATIVER KORRIGIERUNG GEGEN MANDIBULÄRE PROTRUSION MIT HORIZONTALER OSTEOTOMIE IM AUFSTEIGENDEN AST

53 Patienten waren gegen mandibuläre Protrusion mit der Babcock operativen Methode die intraorale Methode von Stenström entwickelt und mit intermaxillärer Fixation mit Hilfe der sog. cap-splints behandelt worden.

Im Laufe von 2 ½ Jahren nach der Operation wurden diese Patienten nachkontrolliert. Ansehnliche Bewegungen des Unterkiefers und der oberen Fragmente wurden entdeckt. Die Lageveränderungen der Fragmente als auch die des Unterkiefers kamen vorwiegend in der Zeit der Fixation vor. Die Bewegungen waren hauptsächlich rotatorisch.

Nach der Fixationszeit wurden, noch 1—1 ½ Jahre nach der Operation, geringe Lageveränderungen der mandibulären Fragmente gefunden. Von dieser Zeit an bis zu 2 ½ Jahren wurden keine signifikanten Veränderungen beobachtet. Die oberen Fragmente scheinen in ihren endgültigen Lagen zu stabilisieren etwa 9 Wochen nach der Operation.

Keine wesentlichen Verschiedungen in der Lageveränderungen in den beiden Gruppen von Patienten waren observiert worden.

Mögliche Erklärungen dieser Bewegungen — vorwiegend rotatorischer Art — sind diskutiert worden.

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