Osteotomy length and postoperative stability in vertical subcondylar ramus osteotomy

Knut Tornes
Department of Maxillofacial Surgery, Haukeland Hospital, University of Bergen, Bergen, Norway

Tornes K. Osteotomy length and postoperative stability in vertical subcondylar ramus osteotomy. Acta Odontol Scand 1989;47:81–88. Oslo. ISSN 0001-6357.

The osteotomy sites in 80 patients treated for mandibular prognathism by intraoral (IVSO) or extraoral (EVSO) vertical subcondylar ramus osteotomy and their relationships to postoperative mandibular stability were studied. A model study demonstrated that metric orthopantomographic measurements of the ramus showed insignificant variability of magnification and distortion. The relative osteotomy length and the bony overlapping area of the osteotomized fragments were evaluated on 6-week postoperative orthopantomograms. High correlation was found between the clinical estimate of osteotomy length and metric registrations. Bony overlapping area of the IVSO and the EVSO group did not reveal differences. The mandibular positional changes during the fixation/postfixation periods were analyzed on 6-week and 6-month postoperative lateral cephalograms. Significant correlations could not be demonstrated between postoperative stability and osteotomy length or overlapping bony area. Thus the osteotomy length appears to be factor of minor importance for postoperative stability. □ *Clinical study; mandibular prognathism; maxillofacial surgery; radiology*

Knut Tornes, Department of Maxillofacial Surgery, Haukeland Hospital, N-5021 Bergen, Norway

Favorable functional results after vertical subcondylar ramus osteotomy for reduction of mandibular prognathism are well documented (1–4). However, some relapse of the initially obtained intermaxillary relationship is to be expected after removal of the fixation (5–11). The reason for this postoperative relapse is not fully understood, and many theories have been discussed (9, 12–14). Åstrand & Ericson (15) documented a relationship between small overlapping bony areas of the fragments and an upward displacement of the gonion point during the fixation period, but this feature did not show any correlation with the late postoperative relapse. During the past decades different types of subcondylar osteotomies have been advocated. The vertical ramus osteotomy originally described by Caldwell & Lettermann (2) stresses that the osteotomy should end anterior to the mandibular angle. The rationale for this anterior extension of the osteotomy line was to provide a better bony contact between the fragments. This osteotomy line is still recommended by various authors for osteotomies both from an extraoral and from an intraoral approach (16–18). Thoma (19) proposed the term oblique osteotomy to include all osteotomies extending from the sigmoid notch to the posterior aspect of the ramus, including the most cranial osteotomy line, the condylotomy, and the caudal line ending at the gonial angle. Series of condylotomies (20, 21), medium-extended osteotomies (1, 6, 22), or completely vertical osteotomies (2, 18) in general appear to obtain acceptable stability. However, at present, no relationships between the osteotomy design and postoperative stability have been documented.

The length of the osteotomy will vary with differences in the anatomy of the individual patient and with the surgeon performing the operation. Since the surgeon can easily control the osteotomy design, this will be of clinical importance if any relations between the osteotomy length and the postoperative stability exist.

This study is focused on assessing metric osteotomy length and analyzing possible systemic differences between left- and right-

Table 1. Sex and age distribution

Procedure	Patients, *n*			Age at surgery, years	
	Female	Male	Total	$\bar{x}$	Range
IVSO	28	12	40	25.8	17–62
EVSO	26	14	40	24.8	17–57
Total	54	26	80	25.3	17–62

sided osteotomies by the extraoral (EVSO) and intraoral (IVSO) procedures. Subsequent to this assessment I evaluated potential effects of the ramus osteotomy design on postoperative stability.

Materials and methods

Patients

Eighty patients with mandibular prognathism were treated with subcondylar osteotomies, 40 through an extraoral and 40 through an intraoral approach (Table 1). Preoperative planning, surgical techniques, and clinical results for this group have been described previously (23, 24).

Radiographic study

Orthopantomograms (Palomex Orthoceph 8) exposed 6 weeks postoperatively were analyzed as to osteotomy length (l), ramus height (h), and the remaining distance (r) of the posterior border (Fig. 1).

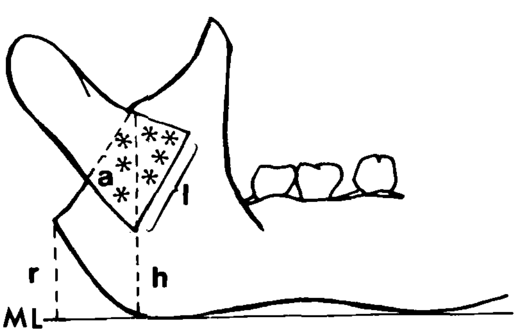

Fig. 1. Illustration of the osteotomy length (l), the ramus height (h), the remaining distance (r) of the posterior border to ML, and the overlapping area (a).

The ratio l/h was calculated. The overlapping bony area of the fragments (a) was calculated with a Houston digitizer (Hi-Pad) and a software calculation program. The orthopantomograms were further evaluated by three experienced oral surgeons, classifying the osteotomies as being short, medium, or long (Fig. 2). Standard profile cephalograms were recorded preoperatively and 6 weeks and 6 months postoperatively and were analyzed to show positional changes in the sagittal plane. Each cephalogram was analyzed with a Houston digitizer (Hi-Pad) interfaced with a computer and a special software program (25). The reference points and lines used were in accordance with the Bergen cephalometric analysis (11). In the present study these cephalometric features were used to describe the changes (Fig. 3): s-n-sm, ML-NSL, s-tgo, n-gn. The mean orthopantomographic measurements of the right and left side of the ramus were compared, as were the EVSO and IVSO groups, and tested for significance with the two-sample *t* test (*t*). To evaluate any influence of osteotomy design and overlapping bony areas on postoperative positional skeletal changes of the mandible, the correlation coefficients between the skeletal positional changes and the mean right- and left-side measurements were calculated. One-way analysis of variance was used to evaluate the stability of the result in three clinical osteotomy classes.

Error of method

Metric measurements in orthopantomograms may include errors due to localization of reference points. The ramus height (h) (Fig. 2) was calculated twice bilaterally from 15 orthopantomograms taken 6 weeks post-

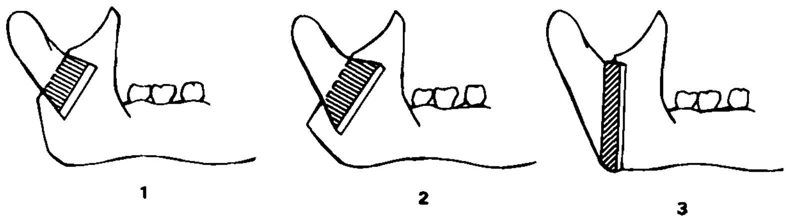

Fig. 2. Classification in short (1), medium (2), and long (3) osteotomy length.

operatively. The measurement error, τ, was calculated from the formula $\tau^2 = \Sigma d^2/2n$, where d is the difference between the first and second values of the ramus height. The value of the measurement error was 0.949 mm, and, on the basis of the paired *t* test, it did not show any significant systematic error. The magnitude of the measurement errors on the cephalograms was insignificant and comparable to those found in other cephalometric studies (11).

Another methodologic error includes magnification of the orthopantomogram due to variation of the radiographic equipment, the anatomical area to be measured, and the direction of the measurement. An experimental model was therefore made to assess this magnification factor of the mandibular ramus area.

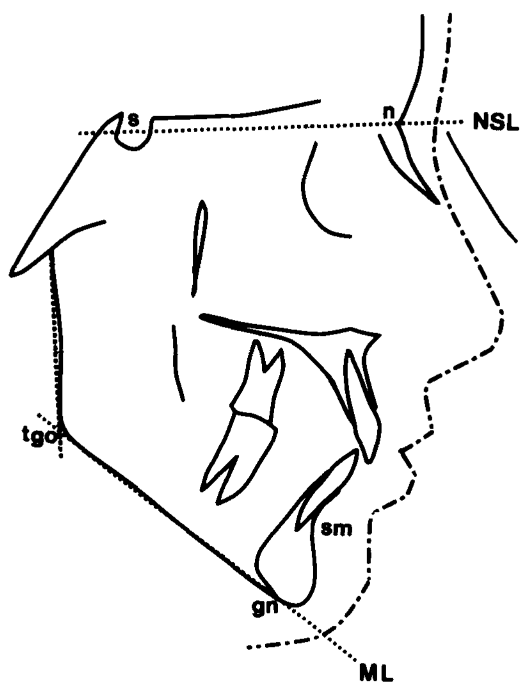

Fig. 3. Reference points and lines.

Model study

Orthopantomograms were taken of a cadaver mandible, in which a long osteotomy had been performed on the right side and a short osteotomy on the left side. The fragments were overlapping in accordance with a posterior mandibular setback of 5 mm (Fig. 4). By performing an additional symphyseal osteotomy the interramal distance could be varied. The magnification factors were calculated for the different reference lines and the overlapping bony areas. The results, tabulated in Table 2, are in agreement with earlier theoretic considerations (26) that objects close to the film show less magnification. In the present model the metric osteotomy length of the proximal fragment had a lower magnification factor because it was located closer to the film than the

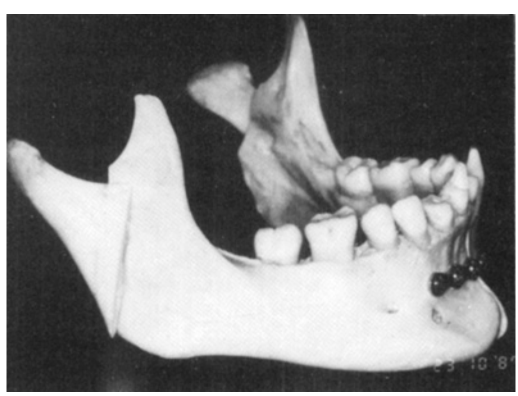

Fig. 4. Model of the mandible with a long osteotomy on the right side and a short one on the left side and a mechanism to adjust the interramus width.

Table 2. The magnification of the overlapping area and the reference lines on the ramus in accordance with the interramus distance

Interramus distance, mm	Right side*				Left side*			
	l	h	r	a	l	h	r	a
97	1.22	1.29	1.31	1.43	1.19	1.20	1.30	1.38
102	1.21	1.28	1.28	1.39	1.18	1.19	1.29	1.32
107	1.20	1.27	1.26	1.28	1.16	1.19	1.26	1.19

* l = osteotomy length; h = ramus height; r = remaining distance of the posterior border; a = overlapping bony area.

measured ramus height. This implies that the width of the mandible should be taken into consideration. However, the variability of the magnification of the reference lines in the present study were insignificant, and consequently, no correction was considered necessary.

Results

Examination of the orthopantograms 6 weeks postoperatively showed the osteotomy length of the IVSO group to be significantly longer on the left ramus than on the right ramus. The l/h ratio and the r values consequently showed significant differences (Table 3). The bony overlapping areas (a) were not related to the osteotomy length.

In the EVSO group right/left discrepancies of the osteotomy length were not found, and the metric osteotomy length was analogous to that of the right side in the IVSO group. Consequently, significant intergroup differences were observed on the left ramus with regard to osteotomy length, the l/h ratio, and to the r values. The bony overlapping area (a) showed a nonsignificant increase on both sides in the IVSO group.

The clinical estimate (Fig. 5) showed more patients from the IVSO than from the EVSO group were in the long osteotomy category, with a predominance of the left ramus side. Analysis of the metric right/left mean values demonstrated good correlation between the clinical classification, true osteotomy length, and the l/h ratio (Table 4). The bony over-

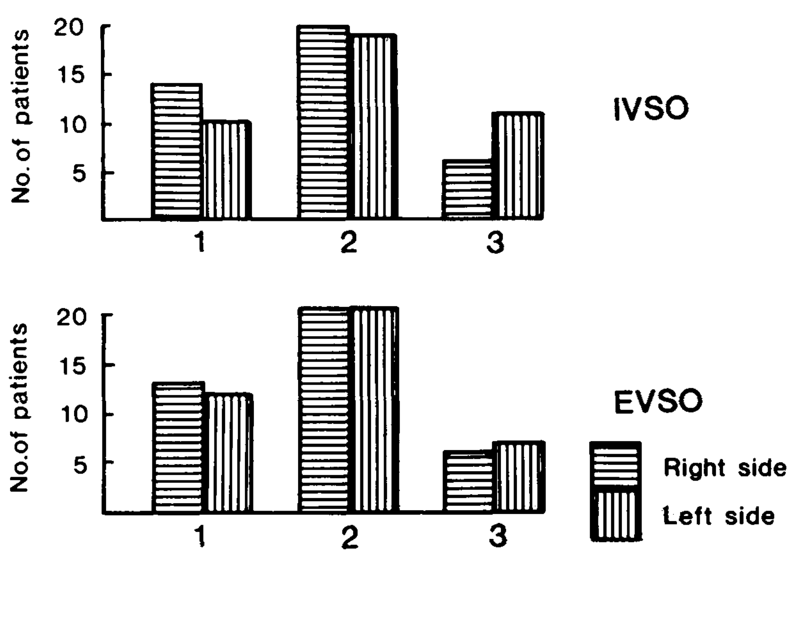

Fig. 5. Distribution of the clinical classification of the osteotomy length on both sides in the IVSO and EVSO groups.

Table 3. Comparison of the osteotomy variables in the IVSO and EVSO groups

	IVSO (n = 40)					EVSO (n = 40)						
	Right side		Left side			Right side		Left side				
	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	t	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	t	Right, t	Left, t
Length, mm	27.72	5.88	29.95	6.95	−2.14*	27.57	4.81	27.07	5.01	0.69	0.12	2.12*
Length/ height, mm	0.62	0.17	0.69	0.19	−3.13**	0.58	0.12	0.58	0.13	0.17	1.06	3.12**
Remaining distance, mm	18.77	8.87	13.50	6.85	4.10**	17.90	6.81	17.37	7.38	0.57	0.49	−2.35*
Area, cm^2	1.67	0.52	1.68	0.49	−0.15	1.51	0.45	1.55	0.47	−0.54	1.50	1.25

* $p < 0.05$; ** $p < 0.01$.

lapping area did not correlate with these values in the same manner. The postoperative positional changes of the mandible implied a posterior rotation of the mandible, a reduction of the posterior facial height, and an increase of the anterior facial height in the intermaxillary fixation period. This was followed by an anterior relapse of the mandible during the next 6 months. A correlation analysis of the cephalometric factors with the l/h ratio, and the overlapping bony area (a) did not show any significant relationship during the fixation or the postfixation period (Table 5).

The mean values of the mandibular changes were analyzed against the clinical osteotomy classification with a one-way analysis of variance (Table 6). During the fixation period a slight but not significantly increased reduction of the posterior face height was observed in patients with short and medium osteotomies compared with those with long osteotomies. The postoperative stability was not significantly influenced whether the osteotomy was short, medium, or long.

No relations were found between metric mandibular setback and osteotomy length. The correlation coefficient between mandibular setback and relapse in the postfixation period, expressed as changes in the s-n-sm angle, did not show any significance.

Discussion

Shepherd (27) demonstrated an orthopantomographic enlargement of 33–44% of the true width of the narrowest part of the ramus. He suggested that it is desirable to calculate the magnification produced by any particular machine before any quantitative studies are undertaken. The magnification of the reference lines in this study was about 1.25 (25%), with insignificant variance related to the interramal width. Åstrand & Ericson (15) observed variations in their orthopantomographic analysis related to magnification. They found different magnification factors of the overlapping bony area by moving the object to the left and right from a mean position. The present

Table 4. Correlation coefficients between different osteotomy characteristics

	Clinical classification	Length	Length/height	Remaining distance
Length	0.64			
Length/height	0.75	0.78		
Remaining distance	−0.76	−0.67	−0.88	
Area	0.33	0.55	0.39	−0.28

model study showed the same pattern, but with a minor magnification factor, most probably due to differences in the radiographic equipment. The smaller magnification of the more superior overlapping area in the left than in the right ramus is due to the anatomic lateral angulation of the ramus. The influence of the angulation of the proximal fragment on the measured overlapping area, as stated by Åstrand & Ericson (15), has not been considered in the present study.

The relevant measure for evaluating the mean osteotomy length is not the metric value, as the maximum length is relative to the ramus height. Thus the ratio l/h and r values appear to represent more relevant figures. The correlation between these factors and true osteotomy length was favorable. Metric osteotomy length and bony overlapping area did not correlate. From a practical point of view, the surgeons' judgement of the osteotomy is important, and a good correlation was observed between these estimates and the true metric values.

In our department we recommended that the ramus osteotomy should end just above the mandibular angle, which means a small remaining distance of the posterior border. However, the present material demonstrated wide variations. The EVSO group had short osteotomies, in general due to short skin incision behind the posterior border of the ramus (24). A submandibular approach offers a better access to the gonial area and may therefore favor a long osteotomy (2, 22, 28). In the IVSO group the osteotomies were somewhat longer on the left side, indicating a technically more convenient access of the oscillating saw on the left side for a right-handed surgeon.

Table 5. Correlation coefficients for the skeletal positional changes of the mandible in the fixation and postfixation periods with the ratio osteotomy length/ramus height (l/h) and with the overlapping bony area (a)

	Fixation period		Postfixation period	
	Area (a)	l/h	Area (a)	l/h
s-n-sm	0.12	0.04	0.10	0.22
ML-NSL	0.03	0.01	0.10	0.14
s-tgo	0.00	0.06	0.11	0.08
n-gn	0.01	0.10	0.05	0.02

Åstrand & Ericson (15) reported a mean overlapping area of 2.58 cm^2 on the right side and 3.00 cm^2 on the left side after extraoral oblique ramus osteotomy. The overlapping area in this study was considerably smaller, even when the compared values were adjusted for magnification factors. The adjusted mean value for the overlapping area found by Åstrand & Ericson (15) was 1.40 cm^2 and in the present study, 1.15 cm^2. The reason for this difference may be less metric mandibular setback and shorter osteotomies in the present study.

Posterior rotation of the mandible and decrease of the posterior face height during the fixation period are regarded as a result of an increased muscular pull on the ramus (5, 9, 29). In the present study the osteotomy length did not significantly influence these positional changes. A slight, but not significantly smaller decrease in the posterior face height in patients with long osteotomies was observed, but relations between overlapping bony area and stability, as found by Åstrand & Ericson (15), were not observed in this period.

Increased muscle influence from the

Table 6. One-way analysis of variance of the skeletal changes of the mandible in the postfixation period in three clinical osteotomy classes

	Clinical classification						
	Short osteotomy (n = 16)		Medium osteotomy (n = 47)		Long osteotomy (n = 17)		
	$\bar{d}$	SD	$\bar{d}$	SD	$\bar{d}$	SD	F
s-n-sm	0.26	1.11	0.23	0.96	0.76	1.06	1.80
ML-NSL	−0.84	2.28	−0.63	1.50	−0.75	1.13	0.11
s-tgo	−0.06	2.96	−0.15	2.26	−0.45	2.16	0.13
n-gn	−1.28	1.44	−0.87	1.21	−0.98	1.36	0.59

tongue (12), occlusal instability (4, 9), and delayed bony healing (14, 30) have been advocated as factors in the anterior relapse after release of the intermaxillary fixation. Correlation between the magnitude of the push-back movement performed at surgery and the degree of relapse after removal of the intermaxillary fixation has been reported by some authors (10, 30). This study, in accordance with other reports (5, 9), did not find such a correlation. Thus a major, single causative factor in the surgical repositioning responsible for this relapse is still lacking (10). The present study demonstrates that the metric osteotomy length is not of major importance for the postoperative stability. Variation in angulation of the proximal fragment (15), resulting in an equal size of the bony contact of a short and a long osteotomy, may be one reason. Further, it has been demonstrated (13, 14) that bony healing after subcondylar vertical osteotomy will take place over a period of more than 6 weeks. Mandibular displacement is found as late as 2 years postoperatively (11, 14). In this situation a stable postoperative occlusion and a good vertical overlapping of the anterior teeth appear to be more important factors to resist those muscular forces that may induce relapse.

Epker & Wolford (17) have pointed out that by making the osteotomy short, the influence of the pterygoid muscles to keep the fragments in contact is reduced. Hall & McKenna (18) recommend long osteotomies without stripping all the muscle attachment on the proximal fragment. However, adequate data in support of this practical advice and postoperative stability are still lacking. Total tissue stripping of the inferior part of the proximal fragment may result in partial vascular necrosis (31), reducing the effect of a long osteotomy. Minimal tissue reflection and stable postoperative occlusion may therefore be more important factors in minimizing the postoperative mandibular positional changes than the design of the vertical subcondylar osteotomy.

Acknowledgement.—I should like to thank Cand. real., Cand. odont. Olav E. Bøe, Dental Faculty, University of Bergen, for valuable advice in the statistical preparation of this paper.

References

1. Åstrand P, Bergljung L, Nord PG. Oblique sliding osteotomy of the mandibular rami in 55 patients with mandibular prognathism. Int J Oral Surg 1973;2:89–101.
2. Caldwell JB, Lettermann GS. Vertical osteotomy in the mandibular rami for correction of prognathism. J Oral Surg 1954;12:185–202.
3. Nordenram Å, Waller Å. Oral-surgical correction of mandibular protrusion. Br J Oral Surg 1968;6:64–74.
4. Wisth PJ. What happened to them. Postoperative survey of patients 10 years after surgical correction of mandibular prognathisms. Am J Orthod 1981; 80:525–35.
5. Åstrand P, Ridell A. Positional changes of the mandible and the upper and lower anterior teeth after oblique sliding osteotomy of the mandibular rami. Scand J Plast Reconstr Surg 1973;7:120–9.
6. Egyedi P, Houwing M, Juten E. The oblique subcondylar osteotomy: report of results of 100 cases. J Oral Surg 1981;39:871–3.
7. Hall HD, Chase DC, Payor LG. Evaluation and refinement of the intraoral vertical subcondylar osteotomy. J Oral Surg 1975;33:333–41.

8. Isaacson RJ, Kopytov OS, Bevis RR, Waite DE. Movement of the proximal and distal segments after mandibular ramus osteotomies. J Oral Surg 1978;36:263–8.
9. Johanson B, Kahnberg KE, Lilja J, Ridell A. Surgical correction of mandibular prognathism by the oblique sliding osteotomy. Scand J Plast Reconstr Surg 1979;13:453–60.
10. Rosenquist B, Rune B, Selvik G. Displacement of the mandible after removal of the intermaxillary fixation following oblique sliding osteotomy. J Maxillofac Surg 1986;14:251-9.
11. Wisth PJ. Pre- and postoperative face morphology of patients with mandibular prognathism [Thesis]. Bergen: University of Bergen, 1986.
12. Hinds EC, Kent JN. Diagnosis and selection of surgical procedures in management of open bite. J Oral Surg 1969;27:939–49.
13. Reitzik M. Cortex-to-cortex healing after mandibular osteotomy. J Oral Maxillofac Surg 1983; 41:658–63.
14. Rosenquist B, Selvik G, Rune B, Petersson A. Stability of the osteotomy site after oblique sliding osteotomy of the mandibular rami. J Cranio Maxillofac Surg 1987;15:14–9.
15. Åstrand P, Ericson S. Relation between fragments after oblique sliding osteotomy of the mandibular rami and its influence on postoperative conditions. Int J Oral Surg 1974;3:49–59.
16. Bell WH, Profitt WR, White RP. Surgical correction of dentofacial deformities. Philadelphia: W. B. Saunders, 1980.
17. Epker BN, Wolford LM. Dentofacial deformities. Surgical-orthodontic correction. St. Louis: C.V. Mosby Company, 1980;41–65.
18. Hall HD, McKenna SJ. Further refinement and evaluation of intraoral vertical ramus osteotomy. J Oral Maxillofac Surg 1987;45:684–8.
19. Thoma KH. Oral surgery. 4th ed. Philadelphia: C.V. Mosby Company, 1963.
20. Spilka CJ. A 25-year study of the closed subcondylar osteotomy for correction of mandibular prognathism. J Oral Surg 1971;29:477–80.
21. Verne D, Polachek R, Shapiro DN. Osteotomy of condylar neck for correction of prognathism: study of fifty-two cases. J Oral Surg 1957;15:183–91.
22. Nystroem E, Rosenquist J, Åstrand P, Nordin T. Intraoral or extraoral approach in oblique sliding osteotomy of the mandibular ramus. J Maxillofac Surg 1985;12:277–82.
23. Tornes K. Extraoral and intraoral vertical subcondylar ramusosteotomy for correction of mandibular prognathism. Int J Oral Surg 1987; 16:9–15.
24. Tornes K, Gilhuus-Moe OT. The surgical technique of vertical subcondylar osteotomy for correction of mandibular prognathism. Acta Odontol Scand 1987;45:203–11.
25. Gjerdet NR. Kefalo. Datasystem for behandling av kefalometriske målinger. Bergen: University of Bergen, 1983.
26. Welander U, McDavid W, Tronje G. Theory of rotational panoramic radiography. In: Langland OE, Langlais RP, Morris CR, eds. Principles and practice of panoramic radiology. Philadelphia: W.B. Saunders, 1982;37–54.
27. Shepherd JP. Changes in the mandibular ramus following osteotomy—a long term review. Br J Oral Surg 1980;18:189–201.
28. Wang JH, Waite DE. Vertical osteotomy vs sagittal split osteotomy of the mandibular ramus: comparison of operative and postoperative factors. J Oral Surg 1975;33:596–600.
29. Rosenquist B, Rune B, Selvik G. Displacement of the mandible during intermaxillary fixation after oblique sliding osteotomy. A stereometric and cephalometric study. J Maxillofac Surg 1985; 13:254–62.
30. Phillips C, Zaytoun HS, Thomas PM, Terry BC. Skeletal alterations following TOVRO or BSSO procedures. Int J Adult Orthod Orthognath Surg 1986;1:203–13.
31. Bell WH, Kennedy JW. Biological basis for vertical ramus osteotomies—a study of bone healing and revascularization in adult rhesus monkeys. J Oral Surg 1976;34:215–24.

Received for publication 21 March 1988