# Section of Odontology

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# Paper

## Assessment of Stability Following Corrective Orthodontic Surgery

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In recent years interest in major orthodontic surgery has become more concerned with the long-term results of this treatment, and a review of the literature shows that in spite of accurate location of the occlusion at operation, and regardless of what techniques are used and what special post-operative precautions are taken, an appreciable number of patients undergoing mandibular ramus osteotomies suffer varying degrees of post-operative relapse (Poulton *et al.* 1963, Egyedi 1965, Köle 1965, Simpson 1974, Vijayaraghavan *et al.* 1974). Relapse is particularly pronounced following the surgical correction of mandibular retrusion (Poulton & Ware 1971, Guernsey & De Champlain 1971, Guernsey 1974).

By contrast, the few long-term assessments of the stability of segmental osteotomies which have been published indicate that the results of these procedures are usually stable, and Bell & Dann (1973) found no changes in the surgically re-positioned bone and only small changes in incisor overbite and overjet in 25 patients following anterior maxillary ostectomies and lower labial segmental procedures.

Many assessments of relapse have been based upon cephalometric measurements and values for mean relapse, and standard error, standard deviation and probability for the samples are given. The measurements are subject to considerable error (Broadway *et al.* 1962), and such statistical calculations indicate only the sample variables. If the measurement errors are not incorporated they are of limited value. Such errors arise from the differences, which can occur, in different films taken of the same subject. These are due to variations in the films, exposure and developing, which may alter the position of reference points on the radiographs, and to posing and posturing errors. They also arise from observer differences in locating points of reference on the same radiograph and from inaccuracies which arise when the measurements are made, either directly or from tracings (Richardson 1966, Baumrind & Frantz 1971, Baumrind *et al.* 1976). Cephalometric radiographs are differential enlargements, the enlargement being greater the farther away the image lies from the point of entry of the central ray, enlargement at the pogonion usually being of the order of 12% in adults. Assessment of measurement errors, in any particular survey, would require repeated X-ray exposures in standard positions on a random sample of the patients under review. From these, repeated measurements could be made and estimates for the posing plus measuring errors be derived for each parameter. In the clinical field this is not acceptable practice, because of the radiation hazards.

Plaster study models offer a more precise means of measuring relapse, but errors in the use of models include tooth movement and the accidental registration of postured bites.

Measurements made directly on patients are subject to considerable inaccuracy and do not appear to have been much used. Various types of sophisticated equipment required for plotting facial contour and form are only available in a few centres.

A review of the literature reveals a justifiable concern with the long-term effects of segmental osteotomies upon the condition of the tooth pulp. Those papers dealing with long term clinical review (Johnson & Hinds 1969, Liebold *et al.* 1971, Hutchinson & MacGregor 1972) present similar findings. In the early postoperative period the teeth in the segment which is moved usually fail to respond to vital pulp testing but a year or so later

70–90% of the teeth involved give normal responses, all the teeth remaining firm and of normal colour unless damaged at the time of operation (Pepersack 1973). Behind these findings is the implication that the teeth are inevitably denervated by the bur cuts in the bone but that the blood supply to the pulp is maintained through a collateral circulation derived from local muscle attachments. This view is supported by the findings of Summers & Booth (1975), who examined the pulps of teeth following anterior maxillary ostectomies carried out in two patients, where extraction of teeth on the segments being moved, but subsequent to ostectomy, had been part of the planned treatment.

Perfusion experiments in animals (Bell 1969, Ware & Ashamalia 1971, Cavanaugh *et al.* 1976, Cavanaugh & Smith 1976, Olson *et al.* 1976, Sokoloski *et al.* 1976) offer corroborative evidence of the maintenance of pulpal blood supply during segmental surgery. However, the few reports of histological changes in the pulp following experimental segmental surgery that have been made are disquieting. Poswillo (1972) carried out 'Wassmund' type procedures in two *M. irus* monkeys and compared the results with 3 control animals in whom selected teeth were subjected to direct trauma. Serial removal of the teeth in their surrounding bone was carried out at different times following these procedures. In the ostectomized animals the pulp showed no evidence of vascular stasis, but loss of odontoblasts, denervation of the pulp and fibrous replacement of the normal pulp stroma was seen. Twenty-four weeks after operation no odontoblasts were present and the pulp stroma was fibrous, containing chronic inflammatory cells but patent blood vessels. No nerve tissue was seen. By contrast, in the traumatized teeth in the control animals, early loss of odontoblasts was succeeded by odontoblastic regeneration.

## METHODS

Patients undergoing major orthodontic surgery in Oxford receive a systematic preoperative assessment and postoperative review. A standard proforma is used in order to promote the entry of the required records and observations at each stage. Patients are reviewed at three months, one year and three years postoperatively. The present survey is based on the records of 184 patients who received major orthodontic surgery in the ten-year period 1966–76. The methods of scrutiny were clinical assessment, cephalometry and direct measurement of plaster study models.

### *Cephalometry*

Mandibular length is of particular interest following mandibular osteotomy and it was measured from articulare to pogonion on cephalometric radiographs, using calipers.

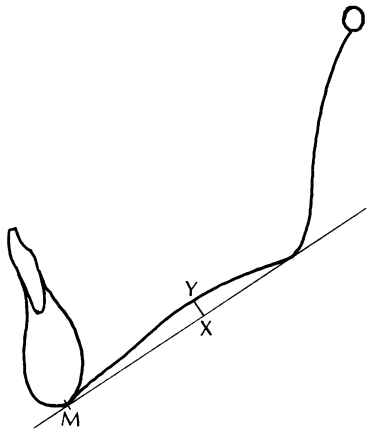


Fig 1 *Method used to define the mandibular plane where the gonion or proximal reference point may be altered by mandibular surgery*

Face height, measured from nasion to menton, was also recorded. Incisor inclinations were related to the line joining the S point to the nasion and to the mandibular plane. The mandibular plane, which proved difficult to define accurately within 5° when related to the S–N line, becomes more inaccurate where the proximal lowest point of the mandible, or the gonion, has been altered by mandibular surgery, and this applies particularly to sagittal split osteotomies. In order to overcome this difficulty the mandibular plane was first drawn on each preoperative cephalogram and a measurement was taken, from the menton (M) to an arbitrary point along this line (X) in the first molar region. A perpendicular was then projected from this point to intersect the lower mandibular border (Y) and the lengths of these two lines (MX and XY) were recorded (Fig 1). Postoperative tracings were based on these datum lines, taking the line MX as the mandibular plane, points M and X being unaltered by the surgery carried out in the ascending ramus.

### *Errors*

In order to assess the measurement error involved in the cephalometric survey, repeated measurements were made on a random selection of individual radiographs and the variations noted. To assess the posing error five lateral cephalometric films were taken of the same subject (the author) by different operators and direct linear measurements and measurements of incisor angulation were made from these films, and compared. The results of these observations were:

*Measurement error* (one observer): (1) Direct measurements of mandibular length (articulare to pogonion): < 1 mm (< 1 %). (2) Measurements of incisor angle (upper and lower) < 5°.
*Posing error:* Mandibular length: < 2 mm (1.8 %).

Cephalometric films taken of a dried skull showed that slight opening of the bite, as occurs when cap splints are worn, produced less than 1 % change in this measurement of mandibular length. Gross mandibular posturing by the patients examined in this survey was not likely to have occurred as all the cephalograms were taken by specialist oral surgery or orthodontic staff. No gross discrepancies between the study models and the relevant cephalograms were noted, but minor posturing errors may have passed undetected.

An additional error can occur in cephalometric machines where the object-film distance is variable. Errors in the measurement of mandibular length of up to 6 mm could result from this source on the machine used in this survey, and these were corrected for.

*Study Models*
Plaster models were used to study occlusal changes and to estimate jaw movement; they were made preoperatively and at three months, one year and three years after operation. A set of planning models in each case was also prepared and sealed with wax in the desired occlusion so that splint models could be correctly articulated. Cap splints incorporating guide pins allowed precise location of the planned occlusion at operation.

For the follow-up survey marks scribed on the buccal aspects of the 1st or 2nd molars allowed measurements of the horizontal changes produced by the operation and by postoperative relapse to be made. Occlusal measurements were also made in all cases to determine changes in arch width and length. Arch width was measured between the distopalatal or distobuccal cusps of the first molars where present. It was assumed for the purpose of this survey, that the distal point of the palatine papilla in the upper jaw, and a point 6 mm below the tip of the lingual gingival papilla between the lower central incisors are stable soft tissue points of reference. Error due to retraction of the lower gingival margin was excluded by recording the length of the clinical crown of the lower incisor. Drift of the molars was revealed by recording the distance from the distolingual cusps to the appropriate soft tissue reference point and corrections made where necessary. Where the setback or advancement, as recorded at the molars, differed on each side the mean value was taken.

Incisor overjet and overbite were measured directly on the plaster models, overbite being recorded as the clearance between the incisal edge of the upper central incisors and the lowest point of the labial gingival margin of the lower incisors, the length of the clinical crown of the lower incisor being compared with the preoperative condition and corrections made where necessary (Fig 2). Normally the left upper and lower central incisors were used to record this measurement.

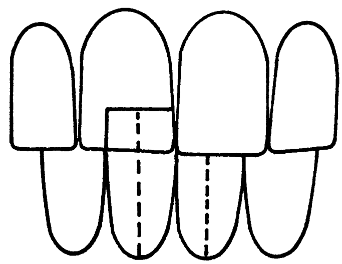

Fig 2 *Method used to measure upper incisal clearance from the lower gingival margins*

*Nerve Function*
Tooth vitality tests were restricted to testing with pledgets of cotton wool soaked in ethyl chloride, and a positive or negative response after approximately 5 seconds application to the labial aspect of the teeth recorded.

Cutaneous sensory nerve function was tested by light touch with cotton wool and recorded as anæsthesia, paræsthesia (impaired response with or without abnormal sensory symptoms), or normal. Weakness or paralysis of the facial musculature was also recorded. These observations were recorded on the first and seventh postoperative days and at three months, one year and three years after operation.

*Table 1*

**Operations performed 1965–76, with age distribution for the principal procedures**

| | No. of patients | Age (years) Mean | Range |
|---|---|---|---|
| Vertical subsigmoid osteotomy (VSS) (Caldwell & Letterman 1964) | 66 | 22 | 15–43 |
| Semicircular subsigmoid osteotomy | 2 | | |
| Obwegeser (1964) osteotomy: | | | |
| Mandibular advancement | 39 | 17 | 13–35 |
| Mandibular set back | 5 | | |
| Lower labial segmental osteotomy (LLS) | 29 | 20 | 16–27 |
| Anterior maxillary ostectomy | 27 | 24 | 13–35 |
| Body ostectomy | 8 | | |
| Dal Pont (1961) osteotomy | 7 | | |
| Winstanley (1968) osteotomy | 4 | | |
| Inverted L ramus osteotomy with bone graft | 3 | | |
| Elevation of upper buccal segments | 3 | | |
| Le Fort I level advancement | 1 | | |
| | 194 | | |

*Table 2*

**Mandibular prognathism: relapse following VSS osteotomy**

| | No. of cases | Mean mandibular shortening (mm) | Mean relapse (mm) at 3 months | Mean relapse (mm) at 1 year |
|---|---|---|---|---|
| Mandibular length (corrected; mean 126 mm) | 25 | 6.7±0.5 (s.d.=2.7) (5%) | 0.7±0.2 (s.d.=0.9) (10%) | 0.7±0.3 (s.d.=1.0) (10%) |
| Occlusal movement | 33 | 7.9±0.5 (s.d.=3.1) | 0.6±0.2 (s.d.=1.2) (7%) | 0.7±0.3 (s.d.=1.1) (9%) |

*Table 3*

**VSS mandibular osteotomy for correction of mandibular prognathism, 33 cases: surgical set back, as measured on models, compared with subsequent mean relapse**

| No. of Patients | Surgical set back (mm) | Mean relapse at 1 year mm | (%) |
|---|---|---|---|
| 1 | 1 | 0 | 0 |
| 0 | 2 | — | — |
| 1 | 3 | 0 | 0 |
| 4 | 4 | 0.2 | 5 |
| 3 | 5 | 0 | 0 |
| 4 | 6 | 0.6 | 10 |
| 4 | 7 | 0.8 | 11 |
| 8 | 8 | 0.9 | 9 |
| 2 | 9 | 1.0 | 11 |
| 1 | 10 | 1.0 | 10 |
| 3 | 11 | 1.5 | 14 |
| 0 | 12 | — | — |
| 2 | 13 | 4.5 | 35 |

*Mandibular Opening*

Jaw gape was measured as the maximum opening in the incisor region. The measurement is inaccurate and is complicated by the horizontal component of mandibular shortening or lengthening and by rotation at operation.

In the period under review 194 operations were carried out (Table 1), 184 of these patients having up to three months postoperative follow up. Patients having incomplete records of a particular observation were excluded from the survey of that parameter.

RESULTS

*Mandibular Prognathism*

The cephalograms of 25 patients and the models of 33 patients, who had undergone vertical subsigmoid mandibular osteotomies (VSS) (Caldwell & Letterman 1954), were studied. Some of these patients had up to moderate degrees of skeletal anterior open bite preoperatively but patients with severe open bites were excluded from this series.

The changes occurring in the horizontal component are shown in Table 2. Mean reduction in mandibular length (corrected for radiographic enlargement) was 6.7 mm and mean relapse at three months and one year, 0.7 mm (10%). The changes, as measured on the models were: mean occlusal set back 7.9 mm, mean relapse at three months 0.6 mm (7%) and at one year 0.7 mm (9%). There was some correlation between amount of set back and degree of relapse (Table 3). Grouped as I, stable (less than 2 mm relapse); II, moderate relapse (2–4 mm relapse); and III, gross relapse (over 4 mm relapse) 30 out of 33 VSS patients fell into Group I, 2 out of 33 into Group II and one into Group III, at one year.

A close correlation between the amount of planned occlusal movement and the consequent change in mandibular length is not always present, the rotational component in mandibular osteotomy contributing to the horizontal change in the position of the pogonion (Fig 3). In 19 random cases with mandibular prognathism the mean reduction in mandibular length was 5.8 mm and the mean molar set back 7.5 mm. In contrast, in 15 random cases with inferior retrusion undergoing mandibular lengthening, the mean values (7.3 mm and 7.2 mm) were comparable (Table 4).

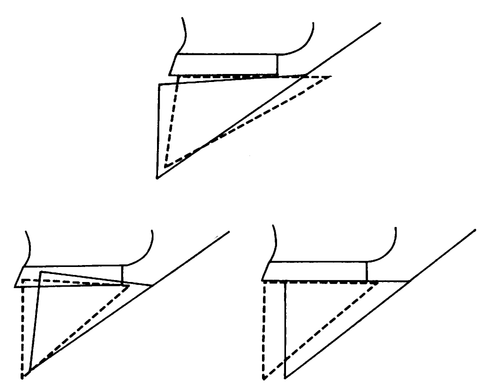

Fig 3 *Diagrams derived from tracings to show that changes in occlusal relationship may be accompanied by different changes in mandibular length according to the rotational element resulting from mandibular osteotomy*

*Table 4*

**Changes in mandibular length (measured from articulare to pogonion and corrected for enlargement), compared with planned occlusal movement**

| | *Reduction in mandibular length (mm)* | *Corresponding molar setback (mm)* | | *Increase in mandibular length (mm)* | *Corresponding molar setback (mm)* |
|---|---|---|---|---|---|
| *VSS* | 3.6 | 5.5 | *Obwegeser* | 9.0 | 10.0 |
| *(19 random* | 7.2 | 13.5 | *forward slide* | 9.0 | 10.0 |
| *cases)* | 12.7 | 8.0 – | *(15 random* | 9.9 | 6.0 – |
| | 9.0 | 8.0 – | *cases)* | 5.4 | 6.0 |
| | 4.5 | 7.5 | | 4.5 | 4.0 – |
| | 3.6 | 8.0 | | 7.2 | 5.0 – |
| | 9.0 | 12.5 | | 9.9 | 7.0 – |
| | 4.5 | 8.0 | | 6.3 | 9.0 |
| | 8.1 | 8.0 – | | 8.1 | 9.0 |
| | 9.0 | 5.5 – | | 4.5 | 6.0 |
| | 4.5 | 6.0 | | 6.3 | 8.0 |
| | 4.5 | 10.5 | | 9.9 | 8.5 |
| | 6.3 | 9.0 | | 9.0 | 10.0 |
| | 5.4 | 8.0 | | 4.5 | 4.5 |
| | 2.7 | 4.0 | | 6.3 | 6.0 |
| | 5.4 | 6.0 | | | |
| | 5.4 | 7.0 | | | |
| | 3.6 | 7.0 | | | |
| | 7.2 | 9.0 | | | |
| Mean | 5.8 | 7.5 | Mean | 7.3 | 7.2 |

The preoperative morphology largely dictates whether, following operation and the change to a normal occlusion, the face height is increased or decreased, or remains unaltered. The mean changes that occurred within these groups were not significant at one year.

*Mandibular Retrusion*

Fourteen patients with complete series of cephalograms and 20 patients with complete sets of models, who had undergone sagittal splitting procedures to lengthen the mandible, were reviewed. These patients were immobilized, at operation, in a planned overcorrected position, with the incisors towards an edge to edge bite, it being anticipated that subsequent moderate relapse would allow the bite to settle back into the desired occlusion. Measurements of mandibular length in the early postoperative (fixation) position and of the amount of planned advancement as measured on the models, are therefore related to the *overcorrected* position. The changes occurring in these patients were: mean increase in mandibular length 7.6 mm, mean relapse at 3 months 1.6 mm (21%) and at one year 1.8 mm (23%). The changes, as measured on the models were: mean advance 7.3 mm, mean relapse at 3 months 2.1 mm (29%) and at one year 2.2 mm (30%) (Table 5). When measured from the estimated desired occlusion, 14 out of 24 had Group I results (under 2 mm relapse), 8 had 2–4 mm relapse (Group II) and two had gross relapse of over 4 mm (Group III) at one year (Table 6).

There appeared to be no correlation between age and degree of relapse (Table 7) nor between degree of advancement and relapse (Table 8). It was noted that one patient advanced 12 mm had relapsed only 3 mm (25%) at one year, whereas another, advanced only 8 mm, suffered a relapse of 5 mm (62%) as measured on models from the overcorrected position. Most of the patients (13/16) in the cephalometric series showed an increase in face height (mean 4 mm) following osteotomy, the changes at one year being minimal.

*Table 5*

**Mandibular retrusion: relapse following Obwegeser (forward slide) osteotomy**

| | *No. of cases* | *Mean mandibular lengthening (mm)* | *Mean relapse (mm) at* | |
|---|---|---|---|---|
| | | | *3 months* | *1 year* |
| Mandibular length (corrected; mean 117 mm) | 14 | 7.6 ± 0.6 (s.d. = 2.2) (7%) | 1.6 ± 0.5 (s.d. = 1.8) (21%) | 1.8 ± 0.4 (s.d. = 1.5) (23%) |
| Occlusal movement | 24 | 7.3 ± 0.4 (s.d. = 2.1) | 2.1 ± 0.4 (s.d. = 1.8) (29%) | 2.2 ± 0.4 (s.d. = 2.0) (30%) |

*Table 6*

**Mandibular retrusion treated by Obwegeser (forward slide) osteotomy: 24 patients, grouped by degree of relapse from desired postoperative occlusion**

| | *Relapse* | *Approximate relapse (%)* | *No. of cases* | *Result* |
|---|---|---|---|---|
| Group I | <2 mm | under 25 | 14 | Stable |
| Group II | 2–4 mm | 25–50 | 8 | Moderate relapse |
| Group III | <4 mm | over 50 | 2 | Severe relapse |

*Table 7*

**Mandibular retrusion treated by Obwegeser (forward slide) mandibular osteotomy: distribution by age in relation to subsequent relapse in 24 patients**

| | *Age (years)* | |
|---|---|---|
| *Group* | *Mean* | *Range* |
| I (Stable) | 17.1 | 14–24 |
| II (Moderate relapse) | 16.4 | 13–19 |
| III (Severe relapse) | 16.5 | 16–17 |

*Table 8*

**Mandibular retrusion treated by Obwegeser (forward slide) mandibular osteotomy, in 24 patients: amount of advancement, as measured on models, compared with subsequent mean relapse, at three months, from planned over-corrected occlusion**

| | | *Mean relapse at 3 months* | |
|---|---|---|---|
| *No. of patients* | *Surgical advancement (mm)* | *(mm)* | *(%)* |
| 3 | 4 | 0.8 | 20 |
| 1 | 5 | 2.0 | 20 |
| 5 | 6 | 2.7 | 45 |
| 4 | 7 | 3.0 | 43 |
| 3 | 8 | 2.0 | 25 |
| 4 | 9 | 2.4 | 26 |
| 2 | 10 | 4.5 | 45 |
| 1 | 12 | 2.0 | 17 |
| 1 | 14 | 9.5 | 68 |

*'Inverted L' Ramus Osteotomy with Rib Graft*

Three severe cases were treated by this technique. In 2 the results were stable at one year, but the third, very severe, case with 20 mm incisor overjet (the upper incisors having normal axial inclinations) sustained Group II–III relapse at one year (Table 9).

*Incisor Angle*

In the Class III cases under review the mean preoperative upper incisor angle was 105° (range 84–126°) and the lower incisor angle 77° (range 58–82°; measurement error <5°). The low mean value for the lower incisors is the expected finding as these teeth come under the influence of pressure from the lower lip in prognathic patients. Threequarters of these cases (18/24) showed no forward movement of the lower incisors one year after operation, although in some patients increase in lower incisor inclination of up to 7° was observed and in one a decrease of 7° was noted.

In the patients with mandibular retrusion, the mean preoperative values were: upper incisors 103° (range 88–116°), lower incisors 93° (range 83–121°). Considerable postoperative changes were noted in these patients, but an appreciable proportion were young and had undergone orthodontic treatment so that movement of the incisors could not be attributed solely to changes in soft tissue influences.

*Labial Segment Surgery*

(1) *Anterior maxillary ostectomy:* Examination of the models of 16 patients showed the results to be stable, there being no increase in incisor overjet or overbite at one year in any case, and in 2 of the patients the overjet had decreased slightly. Four of these patients had midline diastemas treated by midline ostectomy. Three of these showed no recurrence of the diastema at one year, one having a slight relapse of less than 1 mm.

(2) *Lower labial segmental osteotomies:* Angle's class III: Five patients, with complete records,

*Table 9*

**Mandibular retrusion: inverted L ramus osteotomy with rib graft (3 cases)**

| | *Advancement (mm)* | | *Relapse (mm) at:* | | | |
|---|---|---|---|---|---|---|
| | | | *Three months* | | *One year* | |
| *Case No.* | *Mandibular length (corrected)* | *Occlusal* | *Mandibular length* | *Occlusal* | *Mandibular length* | *Occlusal* |
| 1 | 8 | 8 | Nil | Nil | −2 (−25%) | 1.0 (12.5%) |
| 2 | 77 | 8 | Nil | Nil | Nil | Nil |
| 3 | 11 | 12 | 2 (18%) | 5.5 (46%) | 4 (36%) | 6.5 (54%) |

Cases 1 and 2 were stable at three months and one year
Case 3 has suffered Group III relapse

*Table 10*

**Angle's class II division ii malocclusion. Results in 5 cases treated by labial segment surgery**

| | | Upper incisor clearance from lower gingival margin (mm) | | | | | |
|---|---|---|---|---|---|---|---|
| *Case No.* | *Procedure* | *Before operation* | *Planned* | *3 months* | *1 year* | *3 years* | *5 years* |
| 1 | LLS | −2 | 7 | — | 3.5 | 3.5 | 3.5 |
| 2 | LLS | −1 | 4 | 4.0 | 4.0 | 4.5 | 3.5 |
| 3 | ULS+LLS | −2 | 5 | 4.5 | 4.5 | 4.0 | |
| 4 | LLS | −2 | 5 | 4.0 | 2.5 | | |
| 5 | Wassmund | −1 | 4 | 3.0 | 2.5 | | |

who underwent lower labial segmental setbacks for the correction of lower alveolar protrusion were stable at one year. One patient, who showed moderate relapse, had abnormal facial musculature associated with congenital cerebral palsy, and the possibility of relapse had been anticipated in this case.

Angle's class II, division ii: Four cases, having one year follow up, were treated by lower labial segmental surgery or a combination of lower and upper labial segmental surgery. One case had been treated by a Wassmund ostectomy following orthodontic proclination of the upper incisors and extraction of upper first premolars. The indication for treatment in all 4 cases was a deep traumatic incisor overbite and all the patients were over 17 years old. The procedures were designed to correct the deep overbite by surgical lowering of the lower labial segment and/or elevation of the upper, at the same time advancing the crowns of the anterior teeth by a moderate amount to improve the axial inclination and obtain contact between the incisal edges of the lower incisors and the cingulæ of the uppers. Postoperative stability was assessed in terms of the clearance between the upper incisors and the lower gingival margins (Fig 2). Preoperatively there was a negative value for this measurement in all cases. The results are shown in Table 10.

*Mandibular Opening*

Most patients undergoing VSS or Obwegeser osteotomies failed to regain full preoperative mandibular opening (Table 11) although the loss at one year was not functionally significant.

*Nerve Damage*

The effects of osteotomy on peripheral nerve function are shown in Table 12. Of 50 patients who had VSS osteotomies, one still had paræsthesia at one year, but all had normal lip and chin sensation at three years. One case had unilateral facial nerve weakness at seven days which was not present at three months.

In 20 patients having sagittal split osteotomies, 12% (5 nerves in 3 patients) showed persistent

*Table 11*

**Maximum mandibular (incisal) opening following mandibular osteotomy**

| | | After operation | |
|---|---|---|---|
| | *Before operation* | *3 months* | *1 year* |
| *VSS (22 patients)* | | | |
| Mean (mm) | 45 | 36 | 40 |
| Per cent | 100 | 80 | 89 |
| *Obwegeser (8 patients)* | | | |
| Mean (mm) | 41 | 30 | 39 |
| Per cent | 100 | 73 | 94 |

*Table 12*

**Nerve damage following mandibular osteotomy**

| | | | Percentage of patients with nerve damage at: | | | | |
|---|---|---|---|---|---|---|---|
| *Operation* | *No. of patients* | *Nerve damage* | *Day 1* | *Day 7* | *3 months* | *1 year* | *3 years* |
| | | | *Mental nerve* | | | | |
| VSS | 50 | P | 12 | 12 | 8 | 2 | All normal |
| | | X | 8 | 6 | 1 | | All normal |
| Obwegeser | 20 | P | 2 | 18 | 32 | 12 | 12 |
| | | X | 96 | 62 | 22 | | |
| LLS | 7 | P | 21 | 21 | | All normal | |
| | | X | 43 | 43 | 14 | All normal | |
| | | | *Facial nerve* | | | | |
| VSS | 50 | W | 2 | 2 | | | |

P, paræsthesia. X, anæsthesia. W, weakness (motor nerve)

*Table 13*

**Tooth anæsthesia following upper and lower labial segmental osteotomy in 21 patients**

Tooth categories: (1) in segment being moved (a) not adjacent (b) adjacent (mesial) to the vertical osteotomy cuts (2) distal to the cuts and not in segment being moved

| *Category* | *Number of teeth involved* | *Teeth (%) not reacting to ethyl chloride* | | |
|---|---|---|---|---|
| | | *3 months* | *1 year* | *3 years* |
| (1a) | 92 | 63 | 6 | 3 |
| (1b) | 45 | 22 | 16 | 18 |
| (2) | 45 | 22 | 16 | 11 |

No teeth were subsequently extracted or root-filled

paræsthesia at one year and at three years. The 7 patients with complete records who underwent lower labial segmental osteotomies had normal lower lip and chin sensation at one year follow up.

*Tooth Anæsthesia Following Segmental Surgery*
Nonvital response to testing with ethyl chloride of the teeth of 21 patients, following upper and lower labial segmental surgery, are recorded in Table 13. Teeth root-filled or crowned before operation were excluded from these results. The teeth tested were: (1) Teeth in the segment being moved but not adjacent to the vertical ostectomy cuts. (2) Teeth in the segment being moved but adjacent (that is mesial) to the vertical ostectomy cuts (3) Teeth distal to the cuts and not in the segment being moved. Table 13 records the number of teeth failing to react normally to testing and shows that the teeth at greatest risk were those on the segment being moved which were adjacent to the vertical ostectomy cuts (usually upper or lower canines). However, the pulps of 16 out of 45 teeth at one year and 11 out of 45 teeth at three years which were distal to the bone cuts, and not moved in the operation, gave no response and were presumably denervated by the procedures.

DISCUSSION

*Mandibular Osteotomy*
This survey shows that the results of the correction of mandibular prognathism by VSS osteotomy were generally stable. Over half the patients undergoing mandibular advancement by sagittal splitting also had stable results at one year, but 10 out of 24 had unacceptable degrees of relapse, 8 being classified as Group II (having a range of 17–65% occlusal relapse) and 2 as Group III, having gross occlusal relapse of over 4 mm as measured on the models.

In a few patients, treated at the age of 15–16 years, who maintained normal occlusion, subsequent nasomaxillary growth, not equalled by further mandibular growth, resulted in a return to a skeletal II facial appearance at 18 years although the normal occlusion was maintained.

Relapse following mandibular lengthening has been attributed to the stretching of ligaments, lengthening of associated muscles and to occlusal guidance, and precautions were taken in these patients to minimize these effects by stripping and sectioning fascial attachments and by preoperative orthodontic treatment. Care was also taken at operation to force the proximal fragments backwards, when applying the interosseous wires, in order to ensure that the heads of the condyles were not inadvertently pulled forward in the articular fossæ. A study of the models and cephalograms failed to reveal any clear correlation between degree of relapse and preoperative occlusion or immediate postoperative mandibular position. It is interesting to note that there was also no correlation between degree of relapse and age, nor between degree of relapse and amount of mandibular lengthening.

Completely stable results were achieved in 2 of the 3 severe cases that underwent mandibular lengthening by inverted L ramus osteotomies with bone graft; this would seem to contradict the belief that the sphenomandibular ligaments and suprahyoid muscles are important elements producing relapse, as neither of these structures was approached in these operations. The third, very severe, case, although having Group III occlusal relapse only suffered Group II mandibular relapse (<4 mm); some degree of relapse was anticipated in this case in view of the severe preoperative degree of inferior retrusion.

*Incisor Angle*
It was surprising to find that the majority of the patients undergoing surgical correction of mandibular prognathism had no observable change in lower incisor angulation at one year after operation. Osteotomies carried out in the ascending ramus carry the tongue and its attachments backwards. Perhaps a greater degree of postoperative proclination of the lower incisors can be expected following body ostectomies.

*Segmental Surgery*
*Angle's class II, division ii malocclusion:* The results of the few cases treated by labial segmental surgery are encouraging and confirm our belief (Barton & Rayne 1968) that moving teeth in their investing bone surgically in adults is not directly comparable to orthodontic tooth movement in children in terms of subsequent stability. However the results of one to five years review do not exclude the possibility of a very gradual relapse to the preoperative occlusion in these cases.

*Tooth vitality:* This survey supports the general finding that the teeth involved in segmental surgery remain firm and of normal colour, the majority apparently becoming reinnervated. Experimental work has suggested that degenerative replacement of normal pulp tissue by a fibrous but living stroma may occur and review of five or ten years duration is necessary in order to assess the long-term results of these procedures. It would seem to be desirable to restrict their use as much as possible in view of the likelihood that pulpal degeneration is induced, although complications have been rare.

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