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A review of the management of anterior open bite malocclusion

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ABSTRACT: Anterior openbite (AOB) malocclusion is considered one of the most demanding challenges for the orthodontist, as occlusal correction is difficult, facial aesthetics may be unsatisfactory and the incidence of relapse is high.

A retrospective cephalometric study of 19 consecutively treated AOB patients is presented. The follow-up ranged from 12 to 48 months. Several case reports are included to demonstrate a contemporary approach combining orthodontic treatment and orthognathic surgery. The results indicate that overbite was maintained with good vertical skeletal stability. Anteroposterior position was less stable. Posterior facial height was maintained or decreased, and there was no evidence of postsurgical maxillary incisor movement.

It is concluded that occlusal stability and clinical success may be anticipated when certain criteria are adhered to in all phases of treatment, and that a coordinated surgical-orthodontic treatment approach currently offers the best chance of attaining occlusal stability, improved function and satisfactory aesthetics.

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Key words: anterior open bite; orthognathic surgery; stability; overbite; posterior facial height

INTRODUCTION

The problems of treating anterior openbite (AOB) malocclusion by orthodontic means alone have been widely reported in the literature. Occlusal correction is difficult, facial aesthetics may be unsatisfactory, and the incidence of relapse is high.

A closely coordinated surgical-orthodontic treatment approach currently offers the best potential for occlusal stability, improved function, and satisfactory aesthetics.

It is the aim of this paper to review theories of aetiology, diagnostic features, and management of the AOB patient. A retrospective analysis of 19 consecutively treated cases of open bite patients is presented together with several case reports to demonstrate a contemporary approach combining orthodontic treatment and orthognathic surgery.

LITERATURE REVIEW

1. AETIOLOGY OF ANTERIOR OPEN BITE

Anterior open bite has been defined as 'that condition where the upper incisor crowns fail to overlap the incisal third of the lower incisor crowns when the mandible is brought into full occlusion' (Mizrahi 1978). This definition encompasses malocclusions from a mild edge-to-edge incisor relation to more severe forms of vertical dysplasia involving many teeth.

Many potential aetiological factors have been implicated in the development of AOB. A classification was provided by Richardson (1981), and is a convenient framework for review.

Transitional open bite occurs when the permanent incisor teeth are erupting, and corrects spontaneously.

Digit sucking open bite, in a child up to four or five years of age, is considered to be a normal feature of development. It may be a continuation of a transitional open bite, and usually does not result in a permanent malocclusion (Mizrahi 1978). If digit sucking extends into the mixed and permanent dentition an anterior open bite may result (Popovich and Thompson 1973). The habit-induced open bite may spontaneously resolve on cessation of the habit, providing normal skeletal relationships and soft tissue activity are present.

Local pathology such as supernumerary teeth, ankylosis and dilaceration of teeth and cystic lesions may impede eruption and lead to AOB. Skeletal dysplasias such as cleidocranial dysostosis, in which there are multiple unerupted permanent teeth and prolonged retention of deciduous precursors, can also result in AOB.

Anterior open bite, in which the skeletal pattern makes a major contribution in the aetiology of the malocclusion, probably constitutes the major category in the adolescent and adult population (Subtelny and Sakuda 1964). In the pre-pubertal and pubertal periods, dentoalveolar growth may compensate for vertical facial growth in some cases, resulting in spontaneous closure of the open bite, yet others may become progressively more severe with growth (Proffit and Bell 1980, Richardson 1981). The relationship between respiratory pattern and craniofacial growth direction is speculative. Linder-Aronson (1970, 1979) described a tendency to, or the presence of AOB, as a characteristic finding in chronic

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mouthbreathers. He studied a group of children before and after adenoidectomies, and concluded that a change from mouth-breathing to nose-breathing resulted in a return to more normal facial morphology 5 years after surgery. Oral respiration was induced in monkeys by complete obstruction of the nasal passages by Harvold et al. (1981) resulting in increased facial height and gonial angle.

Altered facial morphology and malocclusion developed in all experimental animals although the changes were not uniform. It was concluded that the recruitment of different muscle combinations was responsible for the observed morphological variations.

Considerable variation in opinion exists as to the role of soft tissues, particularly the tongue, in the aetiology of AOB. Tongue activity has been thought to be adaptive in nature (Tulley 1964), or a direct cause of the anterior open bite (Straub 1960). Wallen (1974) reported on the vertical force exerted on the teeth by the tongue in AOB and normal subjects, and found that the force was less in the open bite group. He concluded that the altered swallowing pattern reflected the adaptive nature of tongue activity to the malocclusion.

The size of the tongue is relatively large in a young child, and exerts less influence during puberty and adulthood and this may be responsible for the spontaneous resolution or improvement of the open bite (Cooke 1981).

2. COMPONENTS OF ANTERIOR OPEN BITE

A. Clinical features

Sassouni (1969) described the dominant feature in craniofacial development in skeletal open bite as excessive vertical growth which is expressed in the dentofacial characteristics. Bell (1971) described the features which he considered pathognomonic of skeletal type in AOB deformity: elongation of the lower facial third, disproportion between the middle and lower third of the face, and a steep mandibular plane angle.

Excessive gingival and tooth display, both at rest or on smiling, together with inadequate lip seal and poor lip posture are frequently present and may be accentuated by a short upper lip. Narrow alar bases and lack of chin prominence commonly accompany this form of AOB deformity (Epker and Fish 1977).

Facial characteristics may vary considerably particularly if there is a concomitant anteroposterior discrepancy. Hence, in some cases, chin position may be well balanced or protrusive. A well balanced chin position indicates less skeletal involvement (Proffit and Bell 1980).

B. Cephalometric features

A number of attempts have been made to elucidate the cephalometric features of skeletal anterior open bite (Subtelny and Sakuda 1964, Nahoum 1972, Isaacson et al. 1971, Worms 1971). The common factor appears to be excessive vertical growth; total anterior facial height is usually greater than that of the normal population. Features of sagittal and transverse dysplasias are often superimposed. An increase in maxillary posterior dentoalveolar height has been implicated in open bite cases, however general agreement has not been obtained on this point. Nahoum (1977) described underdevelopment of the maxillary dentition whereas overdevelopment of this area has been reported by others (Sassouni and Nanda 1964, Subtelny and Sakuda 1964).

Occlusal plane angulation to anterior cranial base has been reported as increased or unchanged, depending on construction.

A consistent feature of all subjects is a steep mandibular plane angle considered to be due to backward mandibular rotation, and superior positioning of the condyle and glenoid fossa (Sassouni and Nanda 1964).

Significantly larger gonial angles associated with the large mandibular plane angles have also been reported. Antegonial notching appears frequently (Subtelny and Sakuda 1964, Nahoum 1975, Mizrahi 1978). The mandible may be retrusive with respect to the cranial base, and both mandibular body and ramus may be decreased in length (Lopez-Gavito 1985), or may be of normal length (Subtelny and Sakuda 1964).

Some disagreement exists with regard to the palatal plane angulation; Sassouni and Nanda (1964), Nahoum (1977), and Lopez-Gavito (1985) described a decreased palatal plane angle in relation to sella-nasion plane, while Frost et al. (1980), Lowe (1980), and Ellis et al. (1985) reported a normal angulation.

Total anterior facial height in the open bite group is greater due to an increase in lower anterior facial height. The origin of the dysplasia appears to be below the palate, yet the upper face displays a normal or reduced vertical dimension (Sassouni and Nanda 1964, Richardson 1969, Nahoum 1971, Frost et al. 1980, Ellis, McNamara and Lawrence 1985).

Most authors record a decreased posterior facial height due to a decrease in mandibular ramus height. In general, cranial base deformities are not reported as a consistent feature. However, Subtelny and Sakuda (1964), note a shortened posterior cranial base, and Lopez-Gavito (1985) lists a steep anterior cranial base and shortened nasion-basion distance.

In summary, it is now accepted that the commonly recurring characteristics of AOB are: increased lower anterior facial height, decreased posterior facial height, steep mandibular plane angle, decreased ramus height, and normal to overerupted maxillary anterior teeth.

3. TREATMENT OF ANTERIOR OPEN BITE

Correction of AOB deformity has been reported as among the least successful of all forms of conventional orthodontic treatment. Many cases prove refractory to any type of therapy, and others are unstable on completion of treatment (Epker and Fish 1977). Subtelny and Sakuda (1964) advised that if a real skeletal open bite is evident, the treatment may be impossible. They stated that in some cases, the best treatment may be to avoid orthodontic treatment. Extrusion of anterior teeth can result in unacceptable facial aesthetics, particularly in patients with excessive tooth and gingival display. Nahoum (1975) commented that the treatment of skeletal open bite has been directed towards treatment of the dentition without consideration of the 'anatomic liabilities'.

Conventional orthodontic approaches to the AOB patient will now be reviewed in the convenient categories provided by Epker and Fish (1977).

A. Redirection of growth

In a study of 20 growing patients with backward rotational tendencies, four first premolars were removed and vertical-pull chin cup therapy was instigated for an average of nine months prior to fixed appliance therapy, a significant average decrease in the mandibular plane angle, and closure of all open bites was reported (Pearson 1978). Mandibular autorotation was attributed to reduction in the 'wedging effect' by premolar extraction, retardation of eruption of posterior teeth, and condylar changes. This form of treatment was unsuccessful in non-growing patients.

Graber et al. (1967), also reported on the use of chin cup therapy in effecting closure of open bite in growing patients, and observed that considerable basal change and reduction in treatment time could be obtained.

High pull headgear directed to the posterior maxilla has been utilised in an attempt to inhibit vertical growth, and allow anterior alveolar development. This form of treatment is based on the assumption that overdevelopment of the posterior maxilla is responsible for the deformity (Epker and Fish 1977).

Fränkel (1983) reported the successful treatment of skeletal open bites with the FR IV appliance. He postulated that the insertion of the appliance may lead to 'soft tissue programming' where the mechanoreceptors in the soft tissue around the posterior edges of the buccal shields of the appliance may distract the condyle from the fossa, with compensatory condylar growth. It was acknowledged that the FR appliance does not have any intrusive effect on the maxillary molars or depressive function on the vertical development of the posterior midfacial structures.

Successful results with activator-headgear combinations have been reported by Pfeiffer and Gröbety (1972, 1982), and Stockli and Teuscher (1985), with the potential for vertical control and condylar growth. Using a modified function regulator, Owen (1985) demonstrated closure of open bites in young patients by prevention of molar eruption and subsequent mandibular autorotation.

B. Tooth movement

Molar extractions have been utilised in an attempt to reduce the magnitude of the open bite by forward mandibular rotation. The removal of second molars for correction of open bite has been advocated by Kim (1974), but Mizrahi (1978) recommended the limitation of extractions, if indicated for relief of crowding, to posterior regions of the arch, and advised against attempts to gain space by distal molar movement, as backward mandibular rotation may result.

Despite the closure of AOB by this measure it has been claimed that molar extraction or intrusion would not change the physiological rest position of the mandible, thus leaving total face height unaltered (Nahoum 1977). This concept was supported by Cooke (1980) who believed that it is not possible to reduce the resting length of the mandibular elevator muscles or alter the existing freeway space.

Vertical elastics for the extrusion of anterior teeth have been used but success is anecdotal (Kim 1987, Sperry 1988).

The use of posterior bite planes or tooth positioners in an attempt to intrude the posterior molar teeth has been recommended only when the open bite is minimal (Subtelny and Sakuda 1964). However, it was acknowledged that this form of treatment in the more severe skeletal dysplasia may preclude correction, or result in relapse.

Promising results have been reported by Dellinger (1986) using the Active Vertical Corrector. Posterior teeth are intruded by reciprocal forces obtained from magnets, with subsequent mandibular autorotation. This treatment is combined with headcap and chin strap wear but as yet there is no long term follow up.

C. Habit control

Where tongue thrust is considered to be an aetiological factor, tongue posture and swallowing exercises are claimed to be beneficial in the alteration of resting tongue position.

Success in the resolution of AOB due to habit control often occurs in patients between the ages of 7 and 12 years (Epker and Fish 1977), and during this period, it has been shown that up to 80% of simple open bites resolved spontaneously with growth, (Worms 1971).

It has been recognised that although a tongue thrust may disappear after orthodontic alteration of the environment, the activity may persist and possibly contribute to relapse. This has provided some justification for the exponents of myofunctional therapy. Epker and Fish (1977) advocated myofunctional therapy only for the growing Class I open bite patient with good facial aesthetics and competent lip seal.

In a study of 25 open bite cases in which tongue crib appliances were worn for 6 months, Subtelny and Sakuda (1964) found that the malocclusion remained unchanged, as tongue activity returned to its former pattern on removal of the appliance. Cooke (1980) commented that tongue crib use would eliminate the habit component of AOB. The residual deformity would then be due to the skeletal component.

Lip seal training has been used in the treatment of skeletal AOB (Fränkel 1980). This is claimed to overcome poor postural behaviour of the lips and reestablish normal orofacial dimensions. Fränkel described the FR IV appliance as an exercise device to increase the height of the upper lip, to attain lip competence, and strengthen the anterior vertical muscle chain. Successful treatment utilising a combination of functional appliance therapy and lip seal training in anterior open bite relapse patients was reported by Fränkel and Fränkel (1983). The results were attributed to the establishment of a competent anterior oral seal.

D. Surgical management

While the surgical treatment of the AOB patient has been confined to the mandible (Limberg 1925, Bell and Dann 1973, Delaire 1977, Kahnberg and Widmark 1988) over the past two decades, a trend towards more stable results has been demonstrated with surgical alteration of maxillary position.

Proffit and Bell (1980) stated that approximately 90% of patients with skeletal type AOB deformity are best treated by a combination of surgery and orthodontic treatment. The use of this technique has been reported to provide a predictable and stable means of closing the AOB deformity (Epker and Fish 1978, Frost et al. 1980, Schendel et al. 1976).

Posterior impaction of the maxilla (one-piece or segmental and with or without other skeletal movements) has been consistently reported to be the treatment of choice.

An alternative approach to traditional surgical methods of AOB closure was advocated by Reitzik et al. (1990). It was suggested that closure of the AOB by an inverted 'L' mandibular osteotomy alone combined with rigid internal fixation was sufficient for stable correction in the 16 patients examined. The procedures involved an extraoral approach and a bone graft from the iliac crest. The postoperative and follow-up changes in posterior facial height values were not presented for evaluation.

4. STABILITY

Mizrahi (1978) concluded that the greater the contribution of the skeletal elements to the aetiology, the poorer the prognosis for orthodontic treatment alone.

Lopez-Gavito et al. (1985) studied a group of 41 orthodontically treated AOB subjects, with a median age of 12 years and 5 months at commencement of treatment, and out of retention a minimum of 9.5 years. All were treated with conventional appliance and headgear therapy. More than 35 percent demonstrated a postretention open bite of 3mm or more, and neither the extent of the pretreatment open bite, mandibular plane angle, nor any other single parameter of dentofacial form was a reliable predictor of post treatment stability.

However, the relapse subgroup tended to show less mandibular anterior dental height, less upper anterior facial height, greater lower anterior facial height, and less posterior facial height during the follow-up period.

Retention has been directed toward intrusion of upper posterior teeth or maintenance of upper molar vertical position, thus attempting to match only lower molar vertical increases against posterior facial height increases. Nemeth and Isaacson (1974) suggest the wear of high pull headgear or Milwaukee brace type appliance until growth of the jaws is complete. The same authors examined 13 treated and relapsed open bite cases, contrasting them with 13 similar deep bite patients. Those exhibiting relapse of the AOB relapse showed backward mandibular growth rotation with vertical anterior maxillary growth exceeding posterior facial height increase.

Nahoum (1977) stated that patients with an UFH/LFH ratio below 0.650 are poor risks for conventional orthodontic treatment, and that a surgical procedure should be considered in these cases.

In a group of 13 patients treated by maxillary posterior superior repositioning and orthodontic treatment, Frost et al. (1980) reported stability of correction of AOB over a mean follow-up period of 19 months.

Epker and Fish (1978), in a sample of 13 Class III skeletal open bite patients in which the vertical and transverse deformities in the maxilla and sagittal discrepancy in the mandible were corrected, reported the absence of any relapse tendencies after 3.5 years. These findings were supported by Lello (1987), who studied the stability of 10 consecutive cases of skeletal open bite treated by combined Le Fort I and bilateral sagittal split osteotomies, with an average follow-up period of 6.5 years. Only 3 cases had pre- or post-surgical orthodontic treatment. Three cases showed signs of minimal skeletal relapse of the relocated mandible, but the author considered the overall results to be successful and stable.

In a study of 40 cases of AOB treated by LeFort I osteotomy, (Lansley et al. 1986), four cases relapsed at least 15 months after surgery. Of these, only one had undergone presurgical orthodontic treatment. Relapse in the orthodontically treated case was due to intrusion of the presurgically extruded anterior teeth. Two cases demonstrated retropositioning of the condyles post-operatively.

A recent study by Denison et al. (1989) reviewed a mixed sample including 28 AOB patients treated over an 11 year period by a combined approach. With a mean follow-up period of 3 years (range 1 year - 11 years 9 months), they reported that AOB exhibited reopening beyond incisal overlap and postulated that molar eruption was responsible.

The following study was undertaken to review critically a series of patients who underwent correction of AOB malocclusion using a combination of orthodontic treatment and orthognathic surgery. Three cases are presented to demonstrate the treatment techniques employed.

MATERIALS AND METHODS

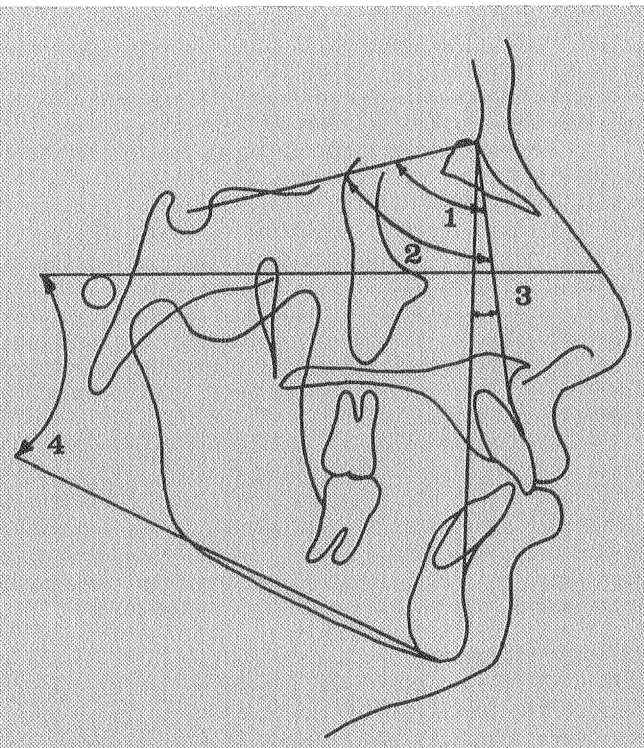
Sample

The study evaluated the lateral cephalometric radiographs of 19 consecutively treated non-growing AOB patients who underwent orthognathic surgery between January 1984 to January 1988.

There were 13 female and 6 male patients and their ages ranged from 15 to 30 years with a mean of 21.4 years. All patients received presurgical and postsurgical orthodontic treatment. The average postoperative follow-up period was 18.5 months (range 12 to 48 months). For the purpose of analysis, the sample was divided into two categories according to skeletal classification: Group 1 - Class III (10 patients), Group 2 - Class I and II (9 patients).

Surgical procedure

All patients underwent superior posterior maxillary repositioning with or without anterior vertical repositioning. In 5 cases the maxilla was segmentalised. Simultaneous mandibular surgery was performed in 13 patients. Horizontal sliding genioplasties were performed for 8 patients. Each surgical procedure was performed by two surgeons using standardised techniques. LeFort I maxillary osteotomies with down-fracture mobilisation and repositioning were undertaken and bilateral sagittal ramus osteotomies were used to reposition the mandible. Wire osteosynthesis and intermaxillary fixation of between 4 - 6 weeks were used for all patients. Surgical splints were fabricated for location of the planned occlusion.



igure 1. Angular Parameters (degrees)

SNA
SNB
ANB
Mandibular Plane Angle

Cephalometric analysis

For each patient standardised cephalometric radiographs in centric relation occlusion with the lips in repose were taken with the same cephalometer (image magnification of 10 per cent). The radiographs were taken after completion of preoperative orthodontics prior to surgery (T1), within 1 week postsurgery (T2), and at least 12 months postoperatively (T3). Four landmarks (A point, ANS, PNS and upper incisor tip - $\underline{1}$), and 10 parameters derived from the cephalometric tracings were used for evaluation (*Figures 1 and 2)*. Cephalometric parameters were selected to demonstrate certain skeletal and dental changes that may have occurred as a result of treatment.

Overall superimpositions were registered using the maximum concurrence of cranial base structures, including the anterior cranial base (Steuer 1972), and the outlines of the frontal and occipital bones. The Frankfort horizontal plane was established as a horizontal reference line and transferred to subsequent films.

Statistical and error analysis

Descriptive statistics including mean and standard deviation by time interval for several variables were generated. The stability of the surgical movements was

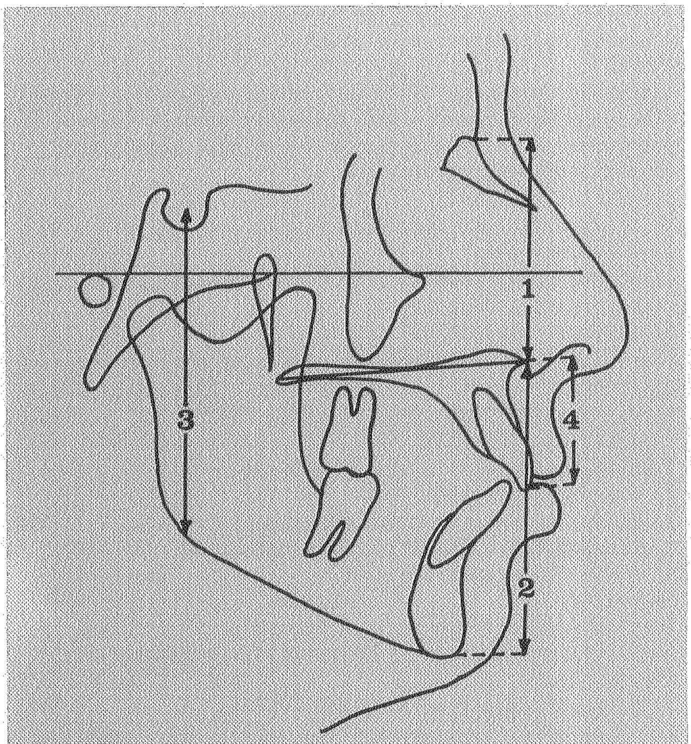


Figure 2. Linear Parameters (mm.)

1. Upper Anterior Facial Height
2. Lower Anterior Facial Height
3. Posterior Facial Height
4. Upper Incisor Tip to Palatal Plane
5. Overbite
6. Overjet

evaluated using the paired t-test and the Wilcoxon Signed Rank Sum Test to compare locations of each hard tissue landmark after surgery (T2) and at recall (T3). Statistical significance was established at $P<0.05$.

Error in landmark identification, tracing and superimposition was determined by tracing, superimposing and measuring the records of three randomly selected patients, i.e. 12 radiographs, a second time. The median value for errors in linear measurement was between 0.5 and 0.9 mm. The 95% Wilcoxon based confidence interval was (0.7,0.95). Angular measurement error had a median value of 1 degree, with a 95% Wilcoxon based confidence interval of (1.0,1.5)

Table 1. Mean surgical movements (mm)

T_1 - T_2

	Total sample (n=19)		Group 1 (n=10)		Group 2 (n=9)	
	Mean	S.D.	Mean	S.D.		
$A_{\Delta H}$	4.18	2.24	4.24	2.78	4.11	1.72
$A_{\Delta V}$	0.83	4.13	1.78	4.83	-0.22	3.11
$ANS_{\Delta H}$	4.28	2.51	3.70	2.99	4.86	1.94
$ANS_{\Delta V}$	0.72	3.79	1.71	4.14	-0.39	3.25
$PNS_{\Delta H}$	5.09	2.74	5.15	2.71	5.02	2.94
$PNS_{\Delta V}$	-3.82	1.65	-3.33	1.29	-4.36	1.91
$1_{\Delta H}$	1.55	3.01	2.35	3.54	0.67	2.17
$1_{\Delta V}$	1.28	3.85	2.16	3.88	0.31	3.80

RESULTS

Surgical movements

The mean surgical movement of the maxilla measured at selected landmarks for all groups is shown in *Table 1.* At point A the mean horizontal advancement was 4.24mm in group 1, 4.11mm in group 2, and 4.18mm for the full sample. Vertical change at A point was 1.78mm for group 1, -0.22mm in group 2, and 0.83mm for the entire sample. Horizontally, ANS and PNS showed similar movements for all groups. PNS was repositioned superiorly by a mean of 3.33mm for group 1 patients, 4.36mm for group 2 patients and by 3.82 for the overall sample. The maxillary incisor tip was moved anteriorly an average of 2.35mm in group 1 patients, 0.67mm in group 2 and 1.56mm for the combined sample, and vertically downwards by a mean of 1.28, 2.16 and 0.31mm for the total group, and groups 1 and 2 respectively.

Table 2. The results of the Wilcoxon Signed Rank Sum Test and the Paired T-test for all groups

	Total sample (n=19)		Group 1 (n=10)		Group 2 (n=9)	
Landmark	P(t-test)	P(w-test)	P(t-test)	P(w-test)	P(t-test)	P(w-test)
$A_{\Delta H}$	0.0007	0.001	0.076	0.018	0.0041	0.009
$A_{\Delta V}$	0.94	0.658	0.91	0.646	1.00	0.722
$ANS_{\Delta H}$	0	0.001	0.060	0.043	0	0.009
$ANS_{\Delta V}$	0.50	0.570	0.61	0.800	0.68	0.779
$PNS_{\Delta H}$	0.012	0.017	0.28	0.418	0.023	0.030
$PNS_{\Delta V}$	0.0069	0.011	0.090	0.108	0.028	0.042
$1_{\Delta H}$	0.96	0.959	0.42	0.333	0.47	0.402
$1_{\Delta V}$	0.016	0.029	0.092	0.185	0.10	0.128

Stability
The results of the Wilcoxon Signed Rank Sum test and the paired t-test for all groups are displayed in *Table 2.* Significant stability of a landmark was established when $P > 0.05$ between T2 and T3. The results indicate that group 1 patients exhibit total stability in all measured parameters. Group 2 showed similar patterns of stability/relapse to the overall group. Points A and ANS were stable in the vertical dimension. Group 2 patients exhibited no relapse in horizontal or vertical position of the maxillary incisor.

The 95% confidence intervals for the unstable parameters *(Table 3)* indicate the direction and magnitude of relapse that may be anticipated for the amount of surgical change that occurred. Similar patterns of movement were demonstrated by group 2 and the total group. The range of anticipated relapse for those maxillary landmarks advanced anteriorly ($ANS_{\triangle H}$ and $PNS_{\triangle H}$) was greater than the relapse of superiorly repositioned landmarks.

Table 4 shows the mean and standard deviations for selected parameters at T1, T2 and T3. All cephalometric parameters approached more 'normal' values postsurgically. The mean mandibular plane angle decreased in all groups postsurgically, as did posterior and anterior facial heights. Group 2 patients demonstrated a mean overall increase in distance of the upper incisor tip to the palatal plane between T1 and T2. This remained unchanged for group 1 patients and the total sample during this period, and also for all groups between T2 and T3. As anticipated, overbite increased in all groups by a similar amount to 2.85 ± 1.06mm for group 1, 2.56 ± 0.92mm for group 2, and 2.71 ± 0.98mm for the complete sample. Group 1 patients exhibited a mean increase in overjet from -5.48 ± 3.68mm to 2.60 ± 0.74mm postsurgically. The overjet decreased in group 2 from 6.11 ± 4.05mm to 2.56 ± 0.73mm.

CASE STUDIES

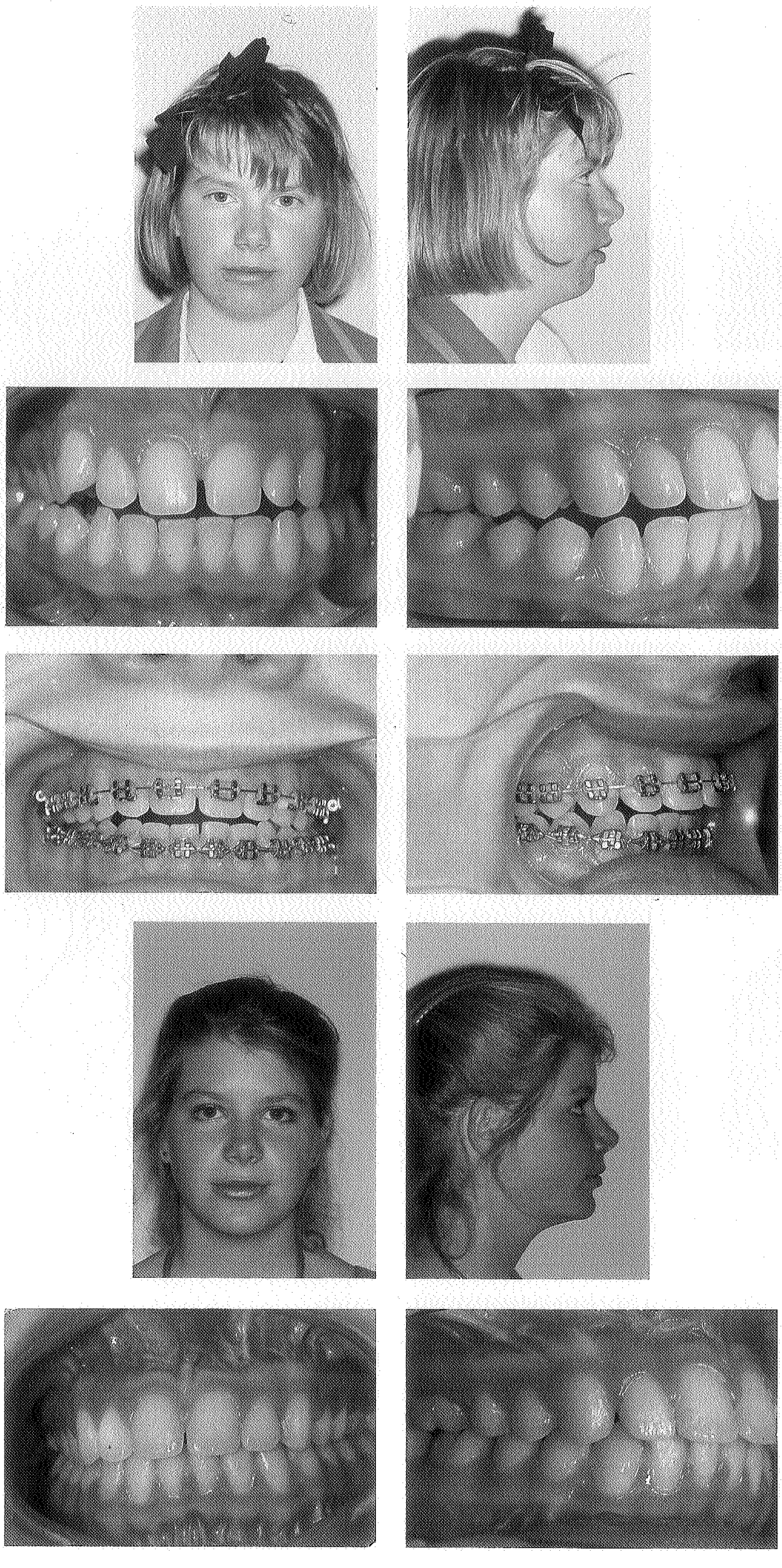
Case 1 *Figure 3(a) - 3(l)*
L.C., a 16 year old girl, initially sought orthodontic treatment for the correction of a diastema between her maxillary central incisors. A history of temporomandibular joint clicking and pain was elicited.
Examination
Frontal
Symmetrical face with well balanced upper and middle thirds. Slightly increased lower anterior facial height. Narrow alar base width. 5mm interlabial gap and 3mm of upper incisor display with the lips relaxed.
Profile
Upturned nasal tip with an obtuse nasolabial angle. Retrognathic mandible with deficiency of soft tissue chin prominence. Short throat-chin length and obtuse angle.
Dental and occlusal analysis
Dental arch form:
Both maxillary and mandibular arches were symmetrical
Dental alignment:
Diastema between maxillary central incisors, upper right canine labial to line of the arch
Occlusion:
Class II division I malocclusion with 6mm overjet, bilateral open bite starting in the molar region. Dental midlines were coincident and corresponded to the facial midline.
Cephalometric analysis
1. Mandibular plane angle 29 degrees
2. Anterior open bite
3. Increased lower anterior facial height
4. Proclination of maxillary and mandibular incisors
5. ANB difference 7 degrees

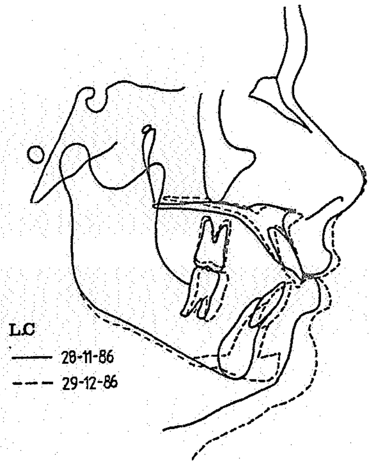
Diagnosis
Vertical posterior maxillary excess with a skeletal anterior open bite and a Class II Division I malocclusion.
Management
1. Surgical removal of four third molars
2. Presurgical orthodontic treatment: Non-extraction alignment and leveling of the maxillary and mandibular arches, avoiding extrusive anterior mechanics
3. Surgical treatment: Repositioning of the maxilla with superior posterior repositioning by a LeFort I osteotomy was performed to provide overbite, decrease the nasolabial angle and shorten anterior facial height. Simultaneously, a bilateral mandibular sagittal osteotomy was performed to correct the sagittal mandibular deficiency and to improve lip posture. This was combined with a genioplasty to advance the chin for improved lip posture and facial balance.
4. Postsurgical orthodontic treatment: Light Class II and anterior vertical elastics. Minor space closure and detailing of the occlusion.

Comment:
The magnitude of the AOB and the severity of the dentofacial disproportion was not marked, yet in order to achieve occlusal correction and good facial balance, bimaxillary osteotomies (with genioplasty) were required. The correction was stable in the follow-up period.

Table 3. 95% Confidence Intervals for unstable parameters (mm)

	Landmark	Confidence Interval of Differences (T_3-T_2)
Total sample (n=19)	$A_{\triangle H}$	(-3.269, -1.054)
	$ANS_{\triangle H}$	(-4.088, -1.700)
	$PNS_{\triangle H}$	(-3.696, -0.541)
	$PNS_{\triangle V}$	(0.539, 2.848)
	$1_{\triangle V}$	(-2.045, -0.240)
Group 2 (n=9)	$A_{\triangle H}$	(-4.775, -1.269)
	$ANS_{\triangle H}$	(-5.262, -2.249)
	$PNS_{\triangle H}$	(-6.21, -0.64)
	$PNS_{\triangle V}$	(0.377, 4.773)





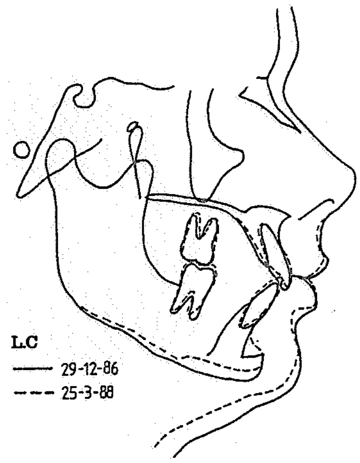
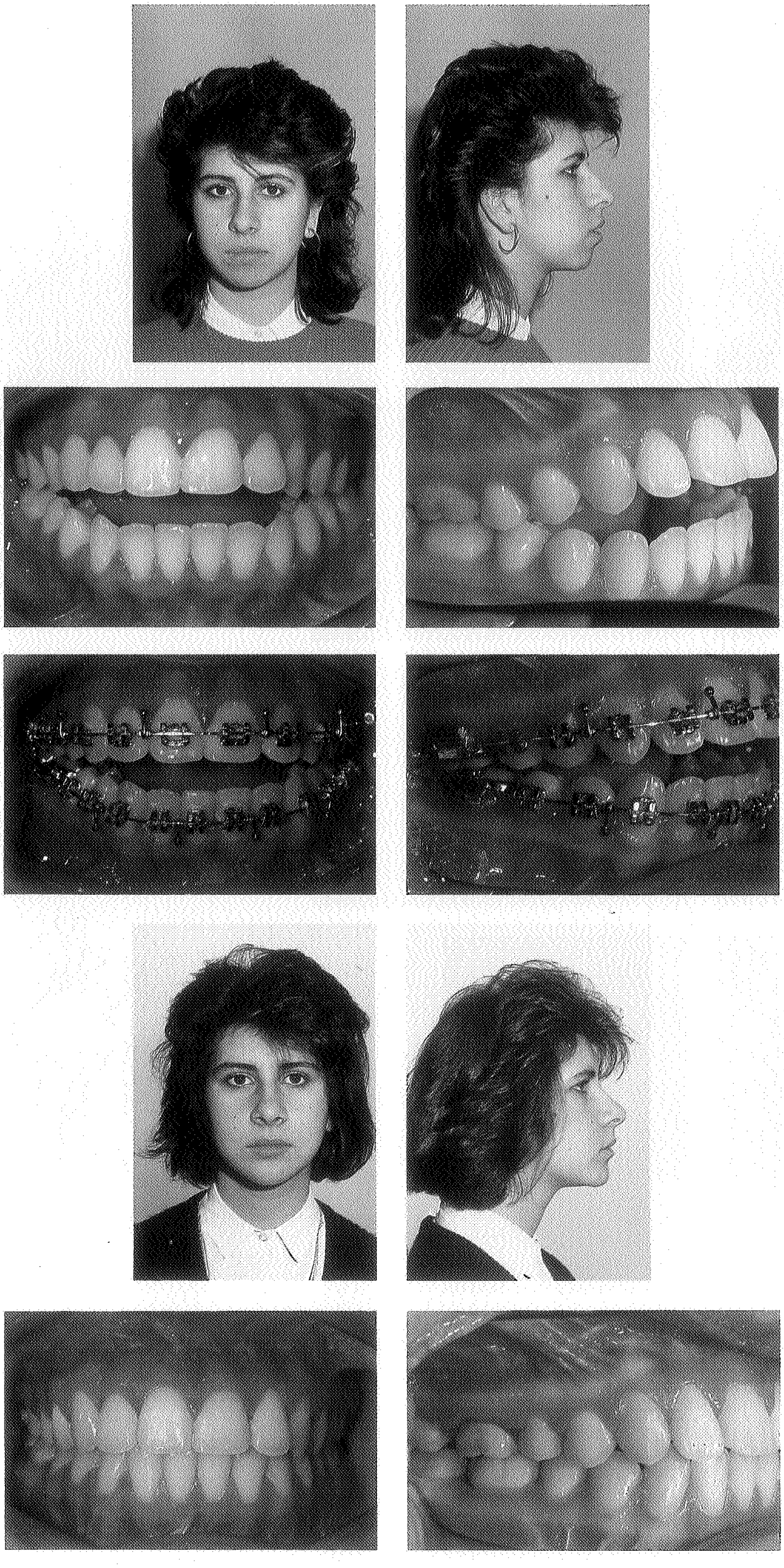
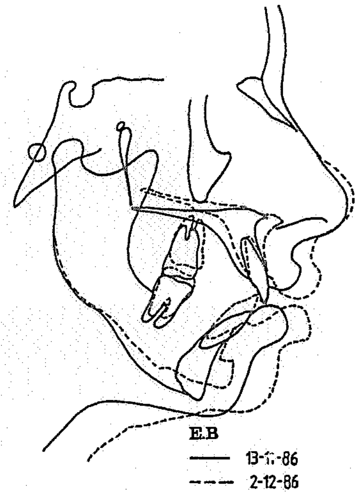


Figure 3.

(a) (b) Pretreatment facial views
(c) (d) Pretreatment intraoral views
(e) (f) Immediate preoperative intraoral views
(g) (h) Posttreatment intraoral views
(k) Cephalometric preoperative and postoperative superimposition
(l) Cephalometric postoperative and follow-up superimposition





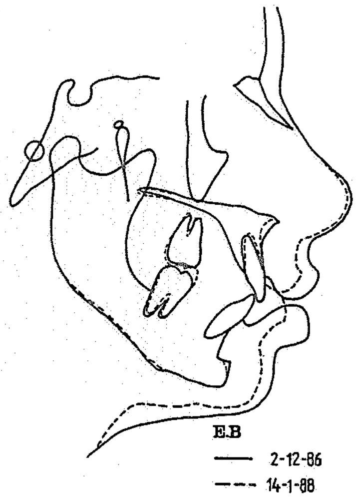
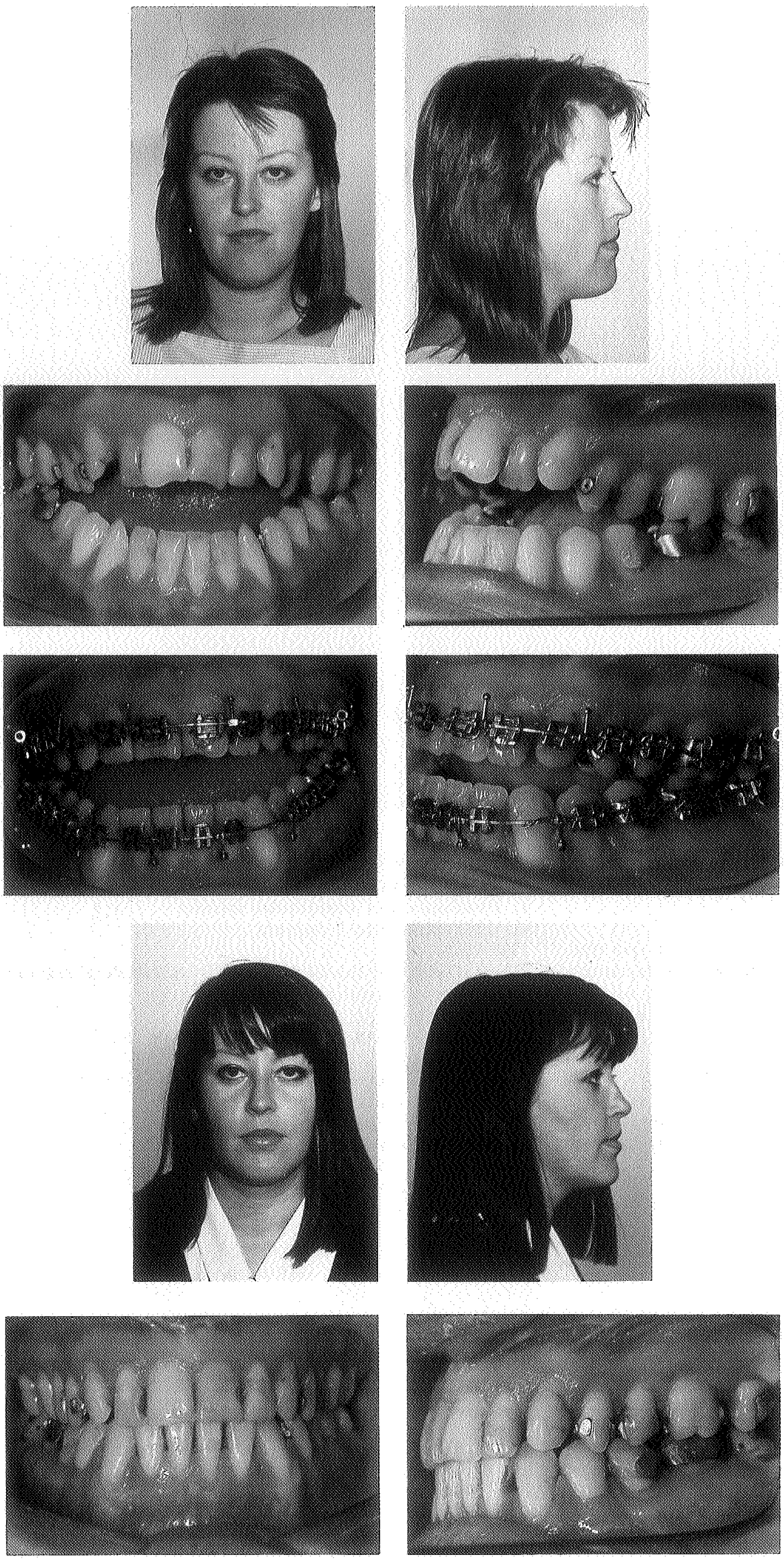
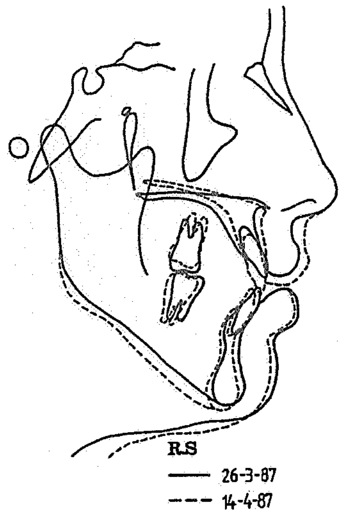


Figure 4.

(a) (b) Pretreatment facial views
(c) (d) Pretreatment intraoral views
(e) (f) Immediate preoperative intraoral views
(g) (h) Posttreatment intraoral views
(k) Cephalometric preoperative and postoperative superimposition
(l) Cephalometric postoperative and follow-up superimposition





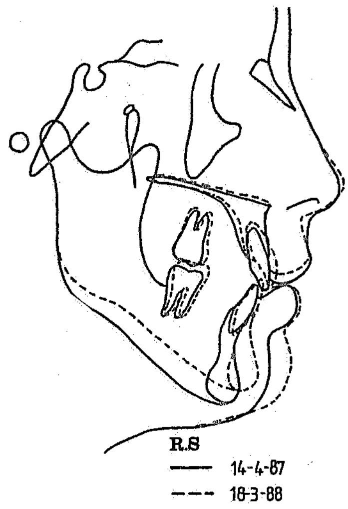


Figure 5.

(a) (b) Pretreatment facial views
(c) (d) Pretreatment intraoral views
(e) (f) Immediate preoperative intraoral views
(g) (h) Posttreatment intraoral views
(k) Cephalometric preoperative and postoperative superimposition
(l) Cephalometric postoperative and follow-up superimposition

Table 4. Linear and angular change for selected parameters

Parameter	Total sample T_1	T_2	T_3	Group 1 T_1	T_2	T_3	Group 2 T_1	T_2	T_3
SNA (deg)	79.32	82.34	81.97	79.40	82.50	82.1	79.22	82.17	81.83
	3.83	3.89	4.18	3.86	4.20	4.43	4.02	3.78	4.14
SNB (deg)	78.58	77.87	78.34	82.0	78.60	79.55	74.78	77.87	76.28
	5.72	3.46	4.13	4.45	3.44	4.03	4.52	3.46	4.03
ANB (deg)	0.74	4.42	3.68	-2.60	3.90	2.55	4.44	5.00	4.94
	5.01	2.42	2.51	3.78	2.60	2.43	3.33	2.19	2.02
Md plane	27.95	28.13	24.34	26.80	29.05	23.65	29.22	27.11	25.11
angle (deg)	5.13	4.17	6.75	6.16	3.59	7.78	3.60	4.73	5.76
ANS-N (mm)	57.67	58.42	58.12	58.28	60.05	59.53	57.0	56.61	56.57
	3.53	4.99	4.36	3.49	5.26	4.61	3.65	4.23	3.69
ANS-Me	78.38	75.29	73.84	80.12	76.70	75.25	76.44	73.72	72.28
(mm)	7.10	6.23	6.83	7.91	6.60	7.33	5.92	5.76	6.26
PFH	85.93	85.37	84.13	87.57	86.70	85.30	84.11	83.89	82.83
(mm)	7.83	7.17	7.41	7.62	6.66	6.97	8.12	7.82	8.07
1 to palatal	30.16	32.58	31.55	30.80	31.70	30.70	29.44	33.56	32.50
plane (mm)	7.55	3.54	3.67	4.02	3.30	3.23	3.79	3.72	4.08
O/J	0.01	2.76	2.58	-5.48	2.80	2.60	6.11	2.72	2.56
(mm)	7.03	0.67	0.71	3.68	0.86	0.74	4.05	0.44	0.73
O/B	-2.53	1.89	2.71	-2.45	1.75	2.85	-2.61	2.06	2.56
(mm)	1.50	1.83	0.98	1.52	2.08	1.06	1.56	1.61	0.92

Total treatment time (appliance placement to deband): 22 months

Case 2 *Figure 4(a) - 4(l)*
E.B., a 17 year old girl, sought treatment for the correction of 'a poor bite'. A history of recurrent temporomandibular joint dysfunction consisting of pain and clicking was elicited but she had no major aesthetic concerns.
Examination
Frontal
Symmetrical facial features with the exception of slight deviation of the chin to the right. 7mm of lip incompetence at rest with 6mm of central incisor crown display beneath the upper lip.
Profile
Increased lower anterior facial height with chin deficiency. Normal nasolabial angle and throat-chin length and angle.
Dental and occlusal analysis
Dental arch form:
Symmetrical maxillary and mandibular arches
Dental alignment:
Well aligned arches with slight crowding and rotations in the upper anterior segment
Occlusion:
Class II Division I malocclusion with 4mm overjet. Bilateral open bite with no contact anterior to the first permanent molars. The maxillary midline was coincident with the facial midline, and the mandibular midline was 2mm. to the left of this.
Cephalometric analysis
1. Dolichofacial pattern
2. Mandibular plane angle 34 degrees
3. Anterior open bite
4. Increased lower anterior facial height
5. Proclination of mandibular incisors
6. ANB difference 7 degrees

Diagnosis
Vertical posterior maxillary excess with a skeletal anterior open bite and microgenia.
Management
1. Surgical removal of impacted third molars
2. Presurgical orthodontic treatment: Non-extraction alignment and leveling of both arches, avoiding extrusive anterior mechanics
3. Surgical treatment: Superior posterior repositioning of the maxilla by a LeFort I osteotomy to provide overbite and decrease lower anterior facial height. This was combined with an advancement genioplasty for improved chin projection.
4. Postsurgical orthodontic treatment: Anterior vertical elastics and detailing of the occlusion.

Comment: Maxillary position remained stable in the follow-up period with the AOB correction achieved by maxillary posterior superior repositioning.
Total treatment time (appliance placement to deband): 20 months

Case 3 *(Figure 5(a) - 5(l)*
R.S., a 28 year old female, presented for treatment of an anterior open bite and improvement in the aesthetics of her anterior teeth. She had experienced temporomandibular joint pain and headaches for some years. At 8 years of age she underwent upper removable appliance and chincup therapy for a two year period.

Examination

Frontal

Slight right deviation of nasal dorsum. Narrow alar base width. Increased lower anterior facial height. 5mm of lip incompetence and 2mm of central incisor crown exposed at rest.

Profile

No obvious dentofacial disproportion. Mild infraorbital and alar base deficiency and normal throat-chin length.

Dental and occlusal analysis

Dental arch form:

Both arches symmetrical

Dental alignment:

Mild crowding of both maxillary and mandibular arches.

Occlusion:

Class I malocclusion. Gross bilateral open bite (5mm anteriorly) with only molar contact. The dental midlines were coincident and corresponded to the facial midline.

Cephalometric analysis

1. Dolichofacial pattern
2. Mandibular plane angle 34 degrees
3. Mandibular incisors retroclined
4. ANB difference 1 degree

Diagnosis

Vertical posterior maxillary excess with a skeletal open bite.

Management

1. Presurgical orthodontic treatment: Non-extraction alignment and leveling of the maxillary and mandibular arches, avoiding extrusive anterior mechanics.
2. Surgical treatment: Repositioning of the maxilla with superior posterior repositioning by a LeFort I osteotomy to provide overbite.
3. Postsurgical orthodontic treatment: Light anterior vertical elastics and occlusal detailing.

Comment: Proclination of the maxillary anterior teeth in the follow-up period with mandibular autorotation occurred, but occlusal stability was maintained.

Total treatment time (appliance placement to deband): 35 months.

DISCUSSION

The frustration experienced by clinicians in successfully treating AOB patients is reflected in the multitude of theories of aetiology and treatment modalities employed over the years. Some clinicians discourage AOB patients from treatment for fear of difficulty and failure.

The results of this study indicate that, for the follow-up period examined, stability in the treatment of AOB patients can be anticipated when a carefully planned combination of pre- and post-orthodontic treatment is combined with orthognathic surgery.

As has been noted in previous studies, all cephalometric parameters approached more 'normal' values postsurgically. This would be expected as the common denominator in the surgical management was maxillary posterior superior repositioning thus shortening the posterior facial height. The stability of maxillary position in the vertical plane was greater than that in the anteroposterior plane. The reasons for this are unclear but neuromuscular adaptation may be greater with a reduction in the vertical dimension where soft tissue factors are not acting to the same degree as with anterior maxillary movements.

An important criterion in the AOB patient is the maintenance of postoperative overbite. Overbite was noted to be maintained in the sample studied and is regarded by the authors as an important determinant of clinical success. Other factors such as posterior disclusion on mandibular excursions and the stability of upper incisor display could be included as criteria for success in prospective studies. It is our observation that minor skeletal relapse, as observed cephalometrically, does not detract either clinically or functionally, provided occlusal stability is maintained.

The mixed results reported by those investigating treatment response in AOB patients may be explained by the potentially vast number of confounding variables. Most studies have been unable to avoid mixed samples and have included differing surgical techniques and varying combinations of procedures. Also the presence or absence of pre- and postoperative orthodontic treatment has often been uncontrolled. A further important variable that has been excluded from consideration by all studies reviewed, including this one, is the length and type of orthodontic retention following appliance removal. To standardise a large sample and to allow a follow-up for any particular subset of dentofacial deformity is difficult due to changing techniques, limited response to recall and the problems of obtaining an homogenous sample.

Various reasons have been advanced to explain the high degree of relapse in the AOB patient. The instability of intruding posterior molars and extruding anterior teeth is thought to be responsible for relapse when conventional orthodontics is performed alone. An increase in posterior facial height following combined surgical and orthodontic treatment is also considered a predisposing factor for relapse. Finn et al. (1980) presented a biomechanical model of the muscular forces that may act upon the surgical sites following bilateral ramus osteotomies. This model provided a further understanding of the factors that may contribute to post-surgical skeletal relapse following alterations in posterior facial height dimension especially when mandibular surgery alone is used to correct the AOB *(Figure 6)*. It would therefore be logical to ensure that any surgical movement in correcting an AOB should be directed towards maintaining or decreasing posterior facial height. A 'myofunctional' model of relapse is proposed to explain the treatment response with an increase in posterior facial height *(Figure 7)*. During initial orthodontic assessment the degree to which an AOB deformity is skeletal in origin should indicate the need for surgery as suggested by Mizrahi (1978).

The role of the tongue musculature in AOB remains controversial. A causative or an adaptive influence remains to be proved or disproved. Several patients within our sample were noted to have obvious tongue thrusting but postoperatively this behaviour appeared to cease. This would suggest that the tongue accommodated to the altered skeletal and dental environment with an apparent neuromuscular adaptation.

To establish a diagnosis and an appropriate treatment plan for any patient with a dentofacial deformity, a comprehensive data base is required. Study models, photographs and a radiological survey may be considered a minimum requirement with additional investigations as indicated.

Treatment is best organised into three phases and certain aspects in each stage are to be carefully considered.

1. Presurgical orthodontic treatment

Occlusal assessment is undertaken to determine dental compensations to be corrected. The need for extractions when arch length deficiency is present (including non-functional third molars) is established and arranged. With a flat occlusal plane, segmental arch alignment is not required, but if a significant Curve of Spee is present, dual occlusal planes will necessitate segmental alignment and if concomitant premolar units have been removed, full space closure can be completed at surgery. It is of great importance that anterior tooth extrusion is avoided presurgically. If some doubt exists, despite cephalometric assessment, as to whether anterior tooth extrusion has occurred, the arch wire may be removed for a period of time (1 to 2 months) and tooth position observed.

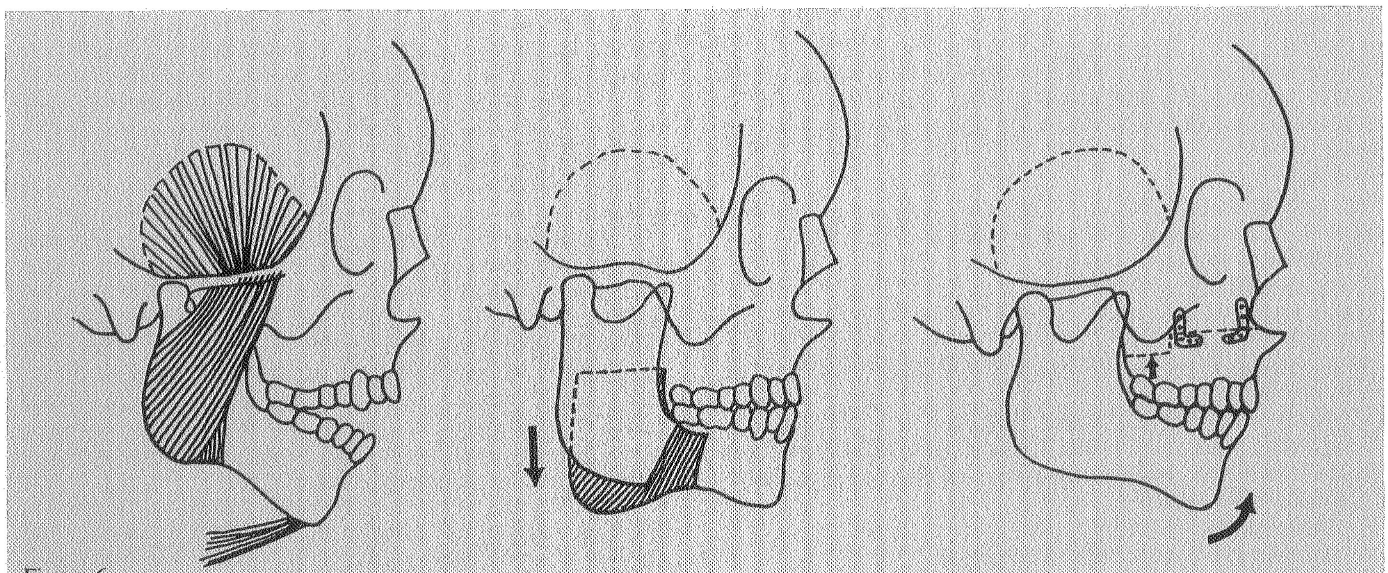


Figure 6.

(a) AOB deformity
(b) Correction of AOB with mandibular surgery alone increases posterior facial height
(c) Maxillary (posterior) superior repositioning allows correction of AOB by mandibular autorotation

↑ Posterior facial height (surgery)
⇩
↑ resting muscle length of 'pterygomasseteric sling'
⇩

Activation of muscles spindles and ↑ in passive tension of connective tissue components	↑ in mechanical advantage of mandibular muscle action
⇩	⇩
Reflex activity to reestablish resting muscle length	Reflex ↑ muscle activity to compensate for the loss of mechanical advantage
⇩	⇩
Shearing stress at healing osteotomy sites	Migration of muscle attachments with bone resorption (remodelling)
⇩	

Early drift of bone fragments and fulcruming on posterior teeth
⇩
Relapse towards AOB

Figure 7. Myofunctional model of relapse

A tooth size discrepancy between arches in the anterior region must be detected and allowance made as this may prevent an adequate cuspid relationship postsurgically. Orthodontic appliances may also interfere with the provision of adequate overbite and can be avoided by careful bracket placement.

2. Orthognathic surgery

The use of wire osteosynthesis and intermaxillary fixation has now been largely replaced by rigid and semi-rigid fixation techniques with bone-plates and screw systems. The adoption of these techniques has highlighted the need for surgical accuracy as there is a greater potential for occlusal discrepancies with function in the early postoperative period. Care must be taken not to distract the condyles from the fossa when seating and stabilising the maxilla in position as opening of the anterior occlusion will occur on release of the temporary intermaxillary fixation.

Segmental surgery is more technically demanding and time consuming. Tooth roots are to be avoided, the blood supply to fragments must be protected and there is greater difficulty in applying rigid fixation. The use of a palatal splint to aid fragment stability has proved to be useful, and slight overcorrection of the overbite is a good insurance for the AOB patient.

3. Postsurgical orthodontic treatment

Early postoperative assessment by the orthodontist is essential to inspect and replace any damaged appliances. Swelling and tenderness in the first two to three weeks may preclude the placement of a continuous arch wire if segmental surgery has been undertaken, but this should be performed as soon as possible to regain control of the complete arch. During the postoperative period, light anterior vertical elastics can be used to maintain overbite and it is preferable to avoid posterior vertical elastics which may extrude the posterior segments and/or teeth. Care should be exercised in executing any posterior molar expansion as tipping of the palatal cusps may unfavourably rotate the mandible. The correct transverse dimension should be achieved either presurgically or at the time of surgery.

Adherence to these principles will provide the best opportunity for a successful outcome in treating the AOB patient. It is obvious that claims of total stability in the long term cannot be made on the basis of this study and follow-up of at least five years would be desirable. It is hoped that the patients in this sample can be reviewed at a later date to improve our understanding of this vertical dentofacial dysplasia which is so difficult to treat.

CONCLUSIONS

1. All patients in the sample either maintained or underwent a decrease of posterior facial height postsurgically.

2. Maxillary incisor position remained stable in the postsurgical period suggesting that extrusive mechanics had not occurred in the presurgical orthodontic period.
3. All cephalometric parameters approached more normal values postsurgically.
4. Overbite was maintained at 1mm or greater at the time of follow-up and may be considered a key component of clinical success.
5. Vertical skeletal movements in the follow-up period were demonstrated to maintain greater stability than those in the anteroposterior dimension.
6. With a well planned approach to both the pre- and postsurgical orthodontic treatment and orthognathic surgery, a high degree of occlusal stability can be achieved in AOB patients, and in many, a significant improvement in facial harmony can be anticipated.

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