Surgical-Orthodontic Stability in Retrognathic Patients

An Implant Study

Dale B. Wade

An extensive literature review and two-year evaluation of the stability of surgical mandibular advancement, using implants in proximal and distal segments. Regression averaged 27% of the initial correction, with most occurring early.

KEY WORDS: • CONDYLE • RELAPSE • SURGERY, ORTHOGNATHIC •

Progressive improvements in surgical and orthodontic procedures over the last few years have brought significant gains in the quality and stability of combined surgical-orthodontic corrections. At one time, oral surgeons and orthodontists both tended to attempt treatment with but a single procedure, with end results very often falling short of the hoped-for objectives. Continued experience with these procedures has brought increasing benefits from the team approach combining the two disciplines to more consistently produce a finer end result.

In critiquing the results of surgical-orthodontic treatment of retrognathic patients, one of the major areas of concern is still stability, both short-term and long-term. It is interesting to note that the subject of stability has only been discussed in any detail in the literature in the last fifteen to seventeen years.

PROFFIT AND WHITE (1970) were among the first to mention relapse after surgical-orthodontic therapy. They felt that relapse could be avoided by concentrating on eliminating the original causes contributing to the original malocclusion as much as possible, and by not operating while patients are still growing.

KENT AND INDOUINA (1970) state that correction of the openbite deformity is one of the most challenging problems. Openbite treated with the combined efforts of surgeon and orthodontist should produce stable results in certain cases; however, regression is seen because of the influence of the tongue, enveloping muscles of the jaw, unusual skeletal features, or bone pathology.

In 1971, WHITE ET. AL. reported on six mandibular advancement patients. He said that the posterior height was always decreased, and the anterior facial height increased post-surgically in all but one patient. In that same year, POULTON AND

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WARE (1971) stated that, "Probably the suprahyoid muscles, which have been lengthened, are the main force contributing to the relapse." They also stated that through intrusion of posterior teeth and extrusion of anterior teeth, the mandible may relapse a considerable distance within 2 or 3 months after surgical intervention without those changes being reflected in the occlusal relationship.

They recommended the use of a shoulder brace, modified from the upper portion of a Milwaukee brace, to counteract the downward and backward pull of the hyoid muscle groups. They also advocated surgical overcorrection. Poulton reported on three cases, with metallic implants placed in the body of the mandible in two cases to serve as markers for future x-ray studies.

Myotomy of the anterior belly of the digastric, mylohyoids, genioglossus, and the geniohyoid muscles is also mentioned as a solution to regression, but has been abandoned because of the threat to the patient's airway.

WICKWIRE ET. AL. (1972) noted the affect of the mandibular osteotomy on tongue position. They felt that the anterior and superior position of he hyoid bone after Class II surgery of the mandible was viewed as another indication of muscle tension, stating that "It appeared, then, that stability of the surgical result would be associated in some way with the stability of the hyoid position."

BEHRMAN (1972) reported on complications after sagittal splitting of the mandibular ramus in 64 respondents to follow-up inquiry. Of all of the complications listed, regression and relapse were the most frequent. This was followed by hemorrhage, disturbances of the mandibular nerve, airway obstruction/edema, fragmentation of ramus, necrosis, infection, and disturbance of the facial nerve.

In 1973, MCNEILL suggested three possible mechanisms for regression:

1. Distraction of the condyle from the glenoid fossa at the time of surgery.
2. Condylar distraction due to healing scar tissue around the osteotomy site.
3. Posterior migration of the anterior mandibular segment in response to tension of the attached muscles and soft tissues during the fixation period.

The second and third possibilities imply some change at the osteotomy site.

STEINHAUSER (1973) reported on six cases of mandibular advancement by sagittal ramus split with suprahyoid myotomy. The anterior bellies of the digastric muscles and the geniohyoid muscles were detached. He noted that it had already been learned from preprosthetic surgical lowering the floor of the mouth that patients need either the mylohyoid or the genioglossus muscle for support of the tongue.

Steinhauser stated that "We think there is less relapse tendency in the mandibular advancement when combined with suprahyoid myotomy, but we cannot yet prove this."

MCNEILL ET. AL. (1973) reported on four cases that showed skeletal relapse during intermaxillary fixation. Lateral cephalometric radiographs were taken before the patient was admitted to the hospital, within 48 hours after surgery, and following fixation. They found 41% mean regression of the surgical correction.

ASTRAND AND RIDELL (1973) reported on a cephalometric study of fifty-five patients that showed postoperative changes in the position of the mandible often occurring after oblique osteotomy of the rami.

MCNEILL (1973) reported on an open bite case with surgical reduction and long-term postsurgical fixation and extraoral traction. Approximately 40% of the achieved skeletal correction relapsed. However, because of the extended fixation period, there was no concomitant loss of the dental correction. He recommended surgical overcorrection, extended intermaxillary fixation, and an extraoral traction device.

Poulton and Ware (1973) showed skeletal changes during maxillomandibular fixation. They measured relapses of 50% to 80%, but improved their results by the use of a neck brace and posterior interocclusal bite opening for several months after surgery.

In 1974, Guernsey reported a retrospective study of six cases. He also found relapse in the immediate postoperative period and while the patients were still in intermaxillary fixation, and suggested suprahyoid myotomy.

Freihofer and Petresevic (1975) concluded from a study of 38 patients that "certainly the procedures lead quite often to a slight change in position of the condyle in the glenoid fossa." Twenty-six showed no postsurgical changes in occlusion. In 8 cases, the overjet increased up to 3mm. Four cases showed over 50% regression. The relapse did not appear to be correlated with the amount of surgical advancement. Accordingly, he considered the surgery successful in 90% of his cases.

In 1975, at the NIDR *State of The Art Workshop* it was reported that "a muscle can be stretched 20% of its length without change." In 1976, Goldspink reported that skeletal muscles will adapt to a physiologic stretching of 40% of their resting length after four weeks of stable skeletal immobilization.

Worms et al. (1976) state that "It is apparent at present that movement of the proximal segment out of the mandibular fossa is a potential source of major error during forward rotating mandibular procedures."

In 1977, Ive et al. reported on a study of 21 patients treated by surgical advancement of the mandible with bilateral sagittal osteotomies of the mandibular rami. The selection was based on good radiographs. The patients' ages ranged from 14 to 43 years, with a mean of 21 years. Three patients also had the mandibular symphysis advanced with a sliding osteotomy. Radiographs were made at five stages:

1. Preoperatively
2. Within 48 hours after surgery
3. Three weeks after surgery
4. Immediately after fixation
5. Six weeks after surgery.

All of the 21 patients demonstrated skeletal changes during the period of maxillomandibular fixation. The authors state that the major postoperative skeletal change occurs during the first few weeks, and that even though the amount of relapse tends to be proportional to the amount of surgical change, these changes are too variable for prediction. Relapses varied from 11% to 71%, with a mean of 30%. The lower facial height was increased in all cases with the advancement of the mandible. There were no discernible patterns that would indicate the existence of a predictable relationship between age and regression.

Farrell and Kent (1977) evaluated the surgical stability of 20 cases of inverted L and C osteotomies. They reported an average relapse of 23% of the amount of mandibular advancement obtained with the C osteotomy, stating that: "The greatest amount of relapse in this series occurs before four months postoperatively." They also note minor relapse in all age groups, with significant amounts of relapse more commonly found in the younger age group.

They agree with other studies that the suprahyoid muscle group is placed under tension in the correction of both skeletal openbite and mandibular retrognathism, suggesting that this muscle group is possibly the main force contributing to skeletal relapse. They suggest that the inverted L or C osteotomies are more reliable operations, but still found relapses up to 50% in some cases.

WOLFORD ET AL. (1978) noted that the mandibular advancement is more stable in low-angle cases and less stable in high-angle cases. As a low-angle mandible is advanced, it usually rotates in an opening direction. There is minimal resistance from the muscles of mastication and suprahyoids. The opposite is true when decreasing the anterior facial height. Proffit has often mentioned that the mandibular plane angle is a lesser problem than the manner in which it is rotated.

EPKER ET AL. (1978) stated in 1978 that — "As a reliable surgical principle, the greater the magnitude of advancement, the greater will be the potential for relapse, all else being equal. . . . It's known that muscles can be stretched or lengthened approximately 15% of their resting length and function physiologically. Muscles do not tolerate greater lengthening." Accordingly, if the distance from the body of the hyoid to the posteroinferior border of the mandibular symphysis in the prediction tracing is greater by more than 15%, they include a digastric and geniohyoid myotomy.

ISAACSON ET AL. (1978) reported on a study of 27 patients treated with mandibular ramus surgery. Nine were retrognathic, with a mean advancement of 8.7mm. The mean regression was 3.7mm (42%). They reported that opening forces act on the anterior segment, and that the anterior maxillary dentition will move vertically 1 to 3mm over six weeks of fixation. This is clearly seen when an orthodontic band loosens at the time of fixation; the tooth with the loose band can easily fall behind the changing occlusal plane before the fixation is removed.

KOHN (1978) studied relapse after mandibular advancement surgery in 17 cases. Nine had sagittal splits, and 8 were treated with C or modified C osteotomies. He reported a loss of 39% of the advancement gained by surgery (17% during fixation and 22% after release of fixation). He attributed the displacement to soft tissue attachments between proximal and anterior segments.

He further proposed compensatory measures, since the cause of skeletal relapse has not been clearly established. These include surgical overcorrection, opening of the posterior occlusion, and external passive restraints (Pitkin collar, modified Milwaukee brace). Although these measures are reported to be of some benefit, ultimate results continue to show significant relapse.

Kohn noted that change in the posture of the neck or the head may very well eliminate the otherwise active force exerted by the anterior strap muscles. It is also noted that inferior movement of the proximal segment, with displacement of the condyle, occurred at the time of the surgery or in the immediate postoperative period. This movement was closely associated with skeletal relapse of the anterior segment.

SCHENDEL ET AL. (1978) report that condyle displacement and dental relapse usually occur with closing rotation and correction of openbite. Ramus procedures associated with opening rotation and correction of deep bites are usually stable, with a good prognosis unless the segments have been fixed in a strained position. They also expect that dentofacial growth following surgery will be harmonious and not adversely affected.

BELL AND JACOBS (1979) pointed out the need for possible maxillary surgery in conjunction with mandibular advancement to allow for autorotation and decrease the tendency for relapse.

POULTON ET AL. (1979) state that, while precise documentation of results is essen-

Fig. 1 **This is patient #4 before and after treatment. She showed the most regression of all twelve cases (53%), and yet it still appears that she benefitted a great deal from the treatment.**

tial, observation of some measure of relapse is not sufficient cause to abandon a procedure. While it is true that many dentofacial problems which would have been considered situations for mandibular advancement several years ago are currently treated by surgical alteration of the maxilla and the chin, using recently developed methods, and that changes obtained in this way appear to be more stable in some circumstances, nevertheless adequate long-term evidence is not yet available for these procedures (Fig. 1).

Reviewing twelve cases of mandibular advancement, they conclude that the use of the neck brace made an important difference in the amount of mandibular advancement that was maintained, which "seems to indicate that some of the relapse is subject to the control of the therapist and the patient."

In 1980, BRAMMER ET AL. studied the stability of maxillary elevation and mandibular surgery in twelve long-face patients with mandibular retrusion. They state that relative superior repositioning of the posterior maxilla was strongly correlated with less mandibular relapse. They saw no correlation of soft cervical collars and suprahyoid myotomies with mandibular stability. Total regression after 8 months was 16%.

REITZIK (1980) advocates a modified fixation technique, stating that positional changes occur between the proximal and anterior segments that lead to a repositioning of the segments in space and in relation to one another. He states further that "If relapse is due to muscular actions on a weak bone scar, why not stiffen the osteotomy site to the extent that it cannot undergo plastic deformation?" He treated nine patients, ranging in age from 17 to

39 years, by surgically advancing the mandible and fixing it with a vitallium mesh plate and screws.

FINN ET AL. (1980) referred to the biomechanical considerations in the surgical correction of mandibular deficiency, stating that at eight weeks, the sagittal split osteotomy site contains focal areas of immature bone and osteoid with incomplete bony healing between the proximal and anterior segments. Under functional loading, this area of osteogenesis is susceptible to the applied bending moments.

Combining superior repositioning of the maxilla with mandibular advancement improves the mechanical advantage of the jaw. The stability of combined maxillomandibular surgery is consistent with the favorable changes observed in the biomechanical model.

SCHENDEL AND EPKER (1980) did a multi-institutional study of 87 cases treated by 20 surgeons, to determine factors that might have contributed to favorable treatment results or relapse, or both, after mandibular advancement. Mean age was 22.3 years. Regression of 25% or less was regarded as excellent stability, and 25% to 50% as moderate stability. More than 50% regression of the surgical correction was regarded as unacceptable stability.

Of the 87 cases, 27 were classified as excellent, 30 moderate, and 30 unacceptable. They concluded that the mandible may be advanced successfully in all types of mandibular deficiency problems, attributing difficulties to surgical technique, such as operative condyle distractions which were consistently associated with relapse.

Positioning the proximal segment and the use of skeletal fixation were considered important in preventing relapse, but the value of suprahyoid myotomy and cervical collars was questioned.

Significant changes in the posture of the head and cervical spine were observed after surgery.

They note that early or immediate postoperative cephalometric radiographs are often not obtained, with stability of results judged on the basis of a later postoperative radiograph obtained weeks or months after surgery. Clearly, this provides a poor indication of true stability, as it fails to record the major relapse that often occurs during the first eight weeks after surgery.

Adequate records are essential to isolating the variables associated with unstable skeletal results, using objective criteria such as percentage of relapse.

Schendel and Epker found that surgical increase in posterior facial height correlated positively with relapse more than any other measurement. They also felt that the length of the fixation period was a factor to be considered; that those cases which were in fixation for 7 weeks showed more regression than those fixed for 10 or 11 weeks.

Many clinicians have considered the suprahyoid muscles to be a major factor in postoperative mandibular relapse. However, there was no statistical difference in the relapse of two comparable groups treated with and without myotomy in this study.

WORMS ET AL. (1980) describe the procedures used to study the problem more closely at the University of Minnesota, where orthognathic surgical patients are routinely evaluated with laminagraphic radiographs of the condyles, cephalometric radiographs, and occasionally implanted markers. They are concerned with seven factors that could contribute to regression:

1. Condyle displacement
2. Condyle resorption
3. Gnathological errors
4. Fibrous union
5. Misdiagnosis
6. Differential treatment planning
7. Proportionality

Longitudinal laminagraphic studies have shown heretofore undocumented condyle resorption. Such condyle resorption occurs in mandibular advancement procedures with either bilateral sagittal splits or bilateral vertical osteotomies. Resorption is most apparent in mandibular advancement procedures that rotate the mandible in a closing direction.

They note that surgical procedures which cause a minimum of matrix distortion may be expected to be the most stable. Mandibular surgical advancements which create an opening rotation appear to be relatively stable, with little distortion of functional patterns.

The futility of mandibular advancement to accomplish closing rotation has been demonstrated by the recent swing to the maxilla as the surgical site of choice for correction of Class II openbite.

An incompletely calcified union may bend, resulting in positional bone changes in response to loads on either the proximal or anterior segment.

Laminagraphic radiographs have revealed positional changes of the bony segments six or eight weeks after vertical osteotomy for class III surgery. Worms states that many postsurgical adjustments take place between bony segments for as long as 10 weeks.

LAKE ET AL. (1981) report a retrospective cephalometric analysis of 52 cases of surgical advancement of the mandible for skeletal and dental changes. The mean surgical advancement was +5.8mm, with 1.5mm (26%) regression after 42 months.

Further analysis of the subgroups demonstrating the most relapse (>3mm or >30%) also demonstrated a significant surgical increase in the gonial arc radius, indicating condyle displacement. Posterior facial height had also been increased. Such alterations at the proximal segment were negligible in the low relapse subgroups.

They found that instability between mandibular segments could be perceived only through the first 7 weeks after surgery, and was negligible thereafter. Movement of the segments in the immediate postoperative period can be linear, rotational, or a combination of both.

They conclude that postsurgical monitoring with fixed implant markers in the proximal and anterior segments, supplemented by laminagraphic radiographs to confirm condyle position and remodeling, would be advantageous to the further development and understanding of mandibular advancement surgery. Accurate appraisal by long-term longitudinal data could provide better approaches to clinical problems and improve the treatment of future patients.

Positional change of the proximal segment was singled out as the most important parameter in the stability or relapse of a surgically advanced mandible, based on a loss of 19.2% of the surgical lengthening in the first few weeks after surgery, and only another 5.5% loss over the next year or more.

WESSBERG ET AL. (1982) drew similar conclusions from a computerized morphometric evaluation of 16 patients. Displacement of one or both mandibular condyles from the glenoid fossae, or inadequate release of the paramandibular connective tissues at the time of surgical advancement of the mandible with sagittal ramus split, are suggested as the primary mechanisms of short-term skeletal relapse. Secondary considerations that may contribute to skeletal relapse are the duration and method of maxillomandibular fixation and the nature of the presurgical orthodontic therapy.

They suggest that suprahyoid myotomy is not essential to skeletal stability following surgical advancement of the mandible if the induced lengthening is less than 30%.

The paramandibular connective tissues exert a prolonged loading of all three segments following surgical advancement of the mandible. Under these circumstances, the muscles of mastication and the suprahyoid muscles create a force across the osteotomy sites, and the enveloping mandibular periosteum and adnexal connective tissues generate a persistent relapsing force on the anterior segment.

They also comment that, although the benefits of fenestrations of the mandibular periosteum at the osteotomy sites is only transient, it reduces the initial relapsing force while segments are properly positioned, and maximizes the attachment of periosteum to the anterior segment of the mandible. However, once healing of the periosteum begins, contracture of the wound again induces a relapsing force across osteotomy sites.

Will (1982) observed condyle changes in 41 patients during fixation, and found them moving superiorly. This was attributed to muscle action and resolution of edema. She found the sum of condyle repositioning observed from preoperative records to 6 weeks after fixation release was in a superior and posterior direction.

Huang and Ross (1982) studied surgical advancement of retrognathic mandibles in 22 growing children. They felt that there were severe growth disturbances after surgery, and that cases that were advanced more than 10mm showed either resorption of the condyle, bizarre bony outgrowths in the posterior symphysis, or both. Those cases advanced less than 9mm experienced milder responses.

Seven cases were evaluated with tantalum implants. They report that, "Although the ligatures were not initially embedded in the ramus, they did not appear to change position in the slightest over the period of observation."

Epker and Wessberg (1982) concur with others when they state that ". . . most skeletal relapse occurs during and immediately following the release of intermaxillary fixation. Immediate postoperative condyle and ascending ramus position and paramandibular connective tissue tension are the two etiologic factors which interact to affect skeletal stability following surgical advancement of the mandible. We consider the paramandibular connective tissues to include skin, interstitial connective tissues, periosteum, and muscles attached to or surrounding the mandible."

They conclude that dental stabilization alone without control of the proximal segment of the mandible results in the greatest likelihood of skeletal relapse following surgical advancement. Prolonged skeletal stabilization with control of the proximal segment of the mandible is suggested as the only practical method currently available for assuring maximum stability.

Bloomquist (1983) suggests a need to improve fixation at the osteotomy site, advocating a single lag-screw at each osteotomy site to control changes between the proximal and anterior segments.

Turpin (1983) suggests that every clinician involved in orthognathic surgery must make a distinction between clinical opinion based on isolated anecdotal experience and established information supported by definitive data. Good records and long-term observation are necessary to assess the results of orthodontic and surgical correction in the treatment of dentofacial deformities.

Kemnitz (1983) studied 13 patients whose surgical/orthodontic treatment included sagittal-split mandibular advancement osteotomies. Le Fort I maxillary impaction osteotomies were also performed on 5 of these patients. Tantalum pins were inserted bilaterally in the proximal and anterior osteotomy segments.

The mean surgical increase in mandibular length was 5.7mm. Relapse after 12 months ranged from 11% to 62%, with a mean of 33% relapse. Nearly all of the postsurgical relapse occurred during the eight-week fixation period. No significant difference was found with suprahyoid myotomy, nor did the magnitude of advancement correlate with the magnitude of relapse.

McMillen (1972) studied condyle position in ten subjects before and during general anesthesia. All had Class I occlusions and no subjective symptoms of temporomandibular joint problems. Cast aluminum clutches were cemented, and there was no undue resistance to operator-guided mandibular border movements. They wore occlusal splints for three days and nights before hinge axis and border movement registrations.

After hinge axis location, intravenous methohexitol sodium 1% (Brevital) was administered to the moderate plane of the surgical stage of general anesthesia. At that time, 10mg of succinylcholine chloride was administered for an initial depolarizing effect. More succinylcholine chloride was then administered in one large dose (50-60mg) to establish total muscle flaccidity. The muscles of mastication were completely relaxed, and exerted no detectable influence on the mandibular movements.

Due to the relaxation of all the muscles of mastication, the mandibular condyles did not remain positioned superiorly in the glenoid fossae. An assistant attempted to keep the condyles seated with support at the angles of the mandible while mandibular border movements were guided by the investigator.

Nasotracheal intubation was not used to maintain an airway, since there was some question of a possible effect on mandibular border movements from the pressure of a nasotracheal tube. During this procedure, 100% oxygen was administered through a small tight-fitting nasal mask.

The assistant was never able to position the condyles as far up and back in the glenoid fossa as they were prior to the administration of general anesthesia. The irreducible displacement of the condyles ranged from 0.9mm to 5.5mm, with a mean of 2.43mm.

— Methods and Materials —

This study is based on a sample of twelve patients with mandibular retrognathia treated with bilateral intraoral sliding mandibular osteotomies. Some maxillary procedure was also done on 11 of these — either maxillary palatal separation, impaction, or advancement. Mandibular surgery included a genioplasty in 8 of the 12 (Fig. 2)

Seven were females and five were males. Age at the time of surgery ranged from 18.460 to 32.634, with a mean of 25.848.

The patients were selected as they presented themselves for mandibular advancement surgery and were kept in the study as long as adequate records could be obtained. Two other were dropped from the study because radiographs were not taken at the proper times. No patients were dropped from the study for any other reason.

Ten were operated by the same oral surgeon, and two by another.

Dental fixation as described by the Author (Wade 1980) was used exclusively on the mandible in 11 of the cases, with supplementary skeletal fixation of the mandible used in one case. Interocclusal surgical splints (not raised in thickness posteriorly) were used in 9 cases, in the other 3 a splint was not considered necessary. The splints were designed to be as this as possible, with several perforations in most of them.

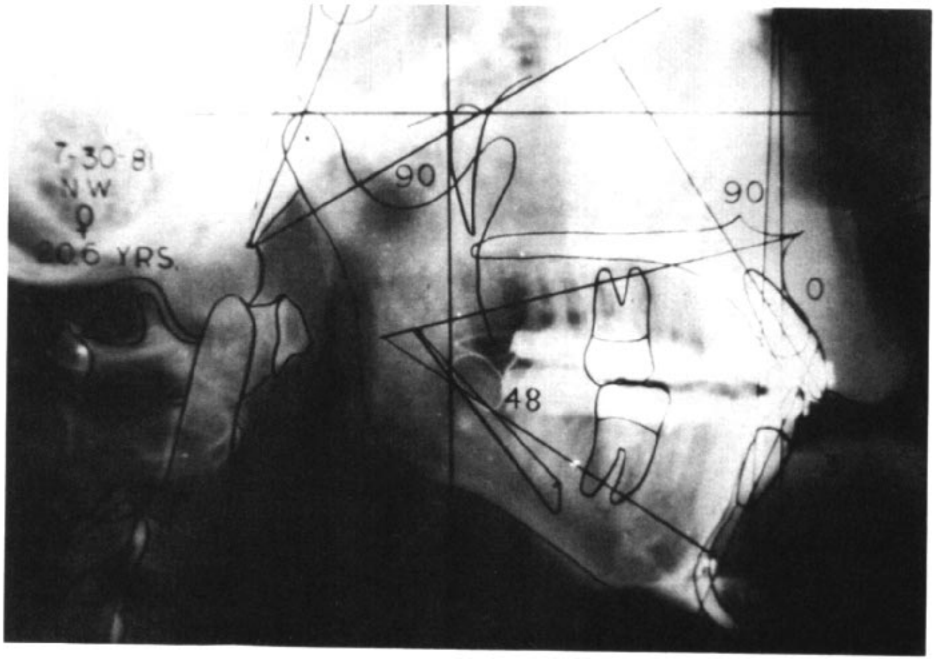


Fig. 2 This patient (#2) had four first bicuspids removed prior to presurgical orthodontics. Her maxilla was impacted, and the mandible advanced. A genioplasty created a 1:1 Holdaway ratio. *(also see Figs. 13 and 14)*

Anterior facial height was decreased in 9 of the cases, and in the other 3 anterior facial height was increased. Suprahyoid myotomy was not performed, and no cervical collars were worn during fixation. Fixation of the proximal and anterior mandibular segments was with conventional bilateral intraosseous wires as described by EPKER AND WESSBERG (1982).

None of the patients was set into an overcorrected position. Mandibular position at the time of surgery was based on a prediction tracing done from a progress headfilm exposed just prior to surgery, and an earlier visualized treatment objective (VTO).

All of these patients were placed on "training elastics" for at least one month following release from intermaxillary fixation.

Lateral cephalometric radiographs were taken at five specific stages:

T-1 Pretreatment

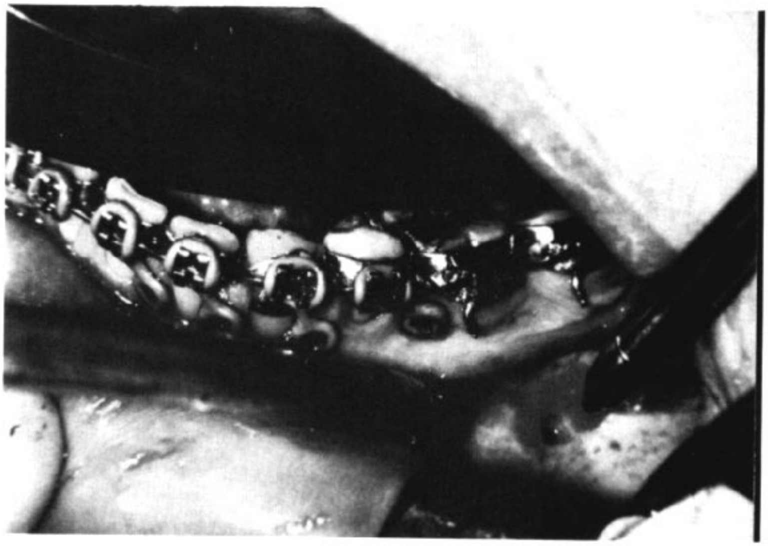
T-2 Within 24 hours after surgery

T-3 Six to eight weeks after surgery, when the patient was taken out of intermaxillary fixation

T-4 Six months after surgery

T-5 Two years or more out of fixation (one of these patients could not be located for this follow-up).

Prior to the surgical split surgery of the mandible, tantalum metallic implants 1.5mm×0.5mm were placed in the left ramus and body as described by BJÖRK (1968) (Figs. 3 and 4). Two were placed on what would be the proximal segment, and two anterior to the intended surgical



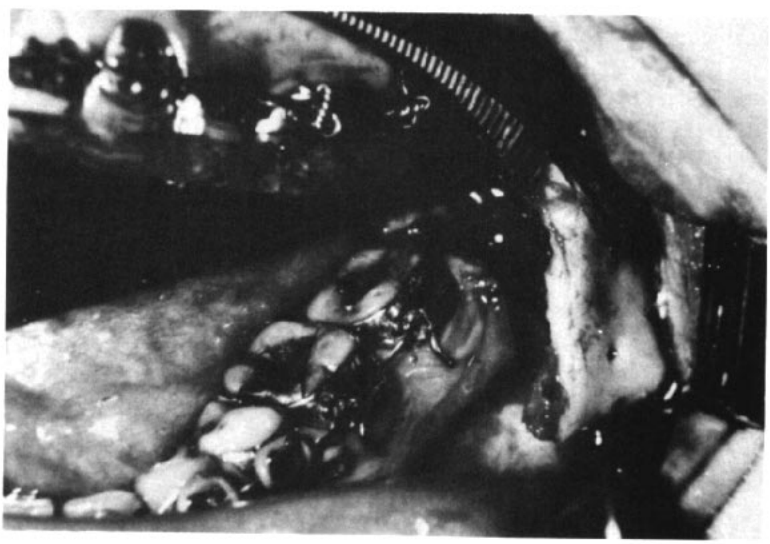


Fig. 3

above **Tantalum implant placed in the future distal segment on the left side.**

below **One of two tantalum implants placed in the proximal segment on the left side.**

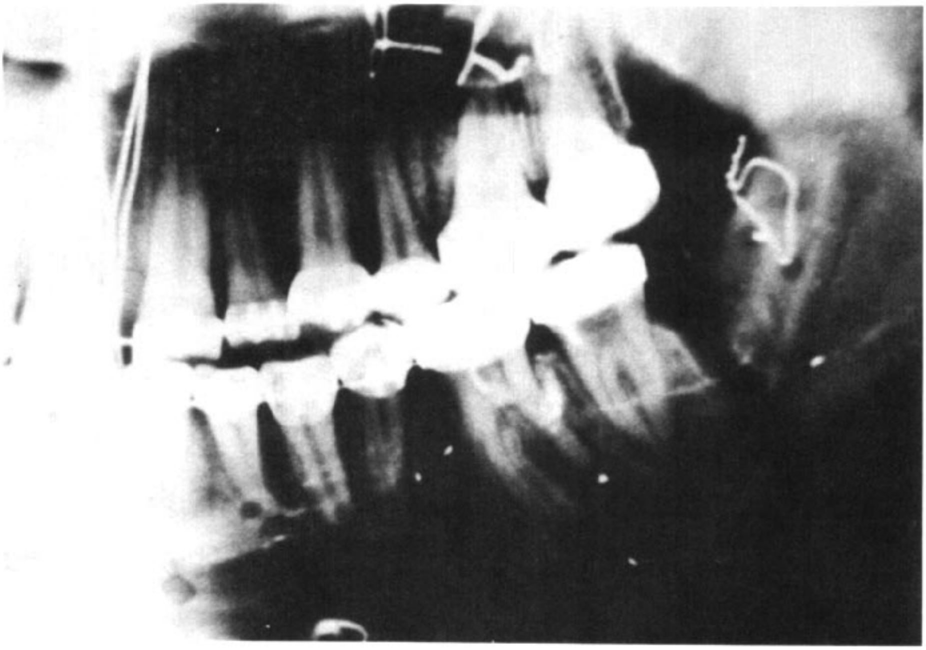


Fig. 4 Panoramic radiograph showing tantalum implants.

site. If one implant should loosen, there would still be three stable references for triangulation between the two segments on future tracings. The implants were all placed far enough away from the planned surgical site that there would be no interaction with osseous healing.

Cephalometric films were traced by the Author. Midpoints between bilateral points and structures were used to generate a common midline reference. The Frankfort horizontal line served as the X-axis in a Cartesian coordinate system, and a vertical through the pterygoid root was used as the Y-axis. The implants were traced and connected to form either a triangle or a quadrangle.

The study was designed to study three specific areas:

First, the amount of horizontal and vertical change produced by the surgical procedure, and the percentage of horizontal regression.

Second, the change at the site of the mandibular sagittal split between the proximal and anterior segments on the patient's left (implant) side.

Third, any correlation between regression and the inferior position of the proximal segment following surgery.

Condyle displacement was determined by transferring the proximal implant images to the original tracing and using the technique described by CREEKMORE (1983). An arc was scribed from the area of condylion to one of the proximal implants. Then the same condyle refer-

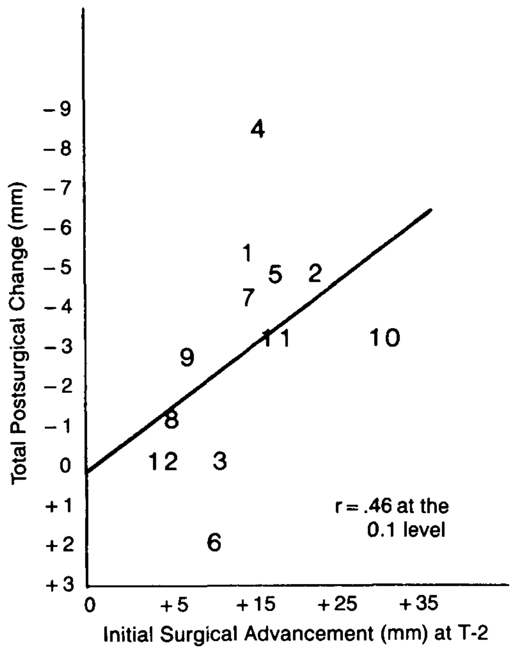


Fig. 5
Postsurgical horizontal change (mm) for 12 subjects, plotted against the horizontal surgical advancement at T-2. Negative values indicate regression.

ence point was used for all succeeding tracings to determine the amount of displacement.

— Findings and Discussion —

Mandibular advancement at pogonion at T-2 ranged from 4mm to 30mm, with a mean advancement of 14.4mm. The large range was partially due to the fact that three procedures were done on many of these patients.

A maxillary impaction will result in some mandibular autoration. Additional length is obtained by the sagittal split of the mandible and possible genioplasty.

At the time that intermaxillary fixation was removed, there was a mean regression of 3.1mm, reducing the mean advancement from 14.4mm to 11.3mm. This is a 19% average relapse. The change from T-2 to T-3 ranged from −6mm (regression) to +2mm (advancement) at pogonion. This represents the combined effects of the sliding ramus osteotomy, genial osteotomy, and autorotation from maxillary impaction.

Six-month postoperative films (T-4) showed little further change. Mean regression from T-3 was only .09mm, or 1%, with 6-month changes ranging from +2mm to −3mm. The Pearson product-moment correlation coefficient was used to test the significance of the amount of advancement against the amount of regression (Fig. 5). The r value was 0.46,

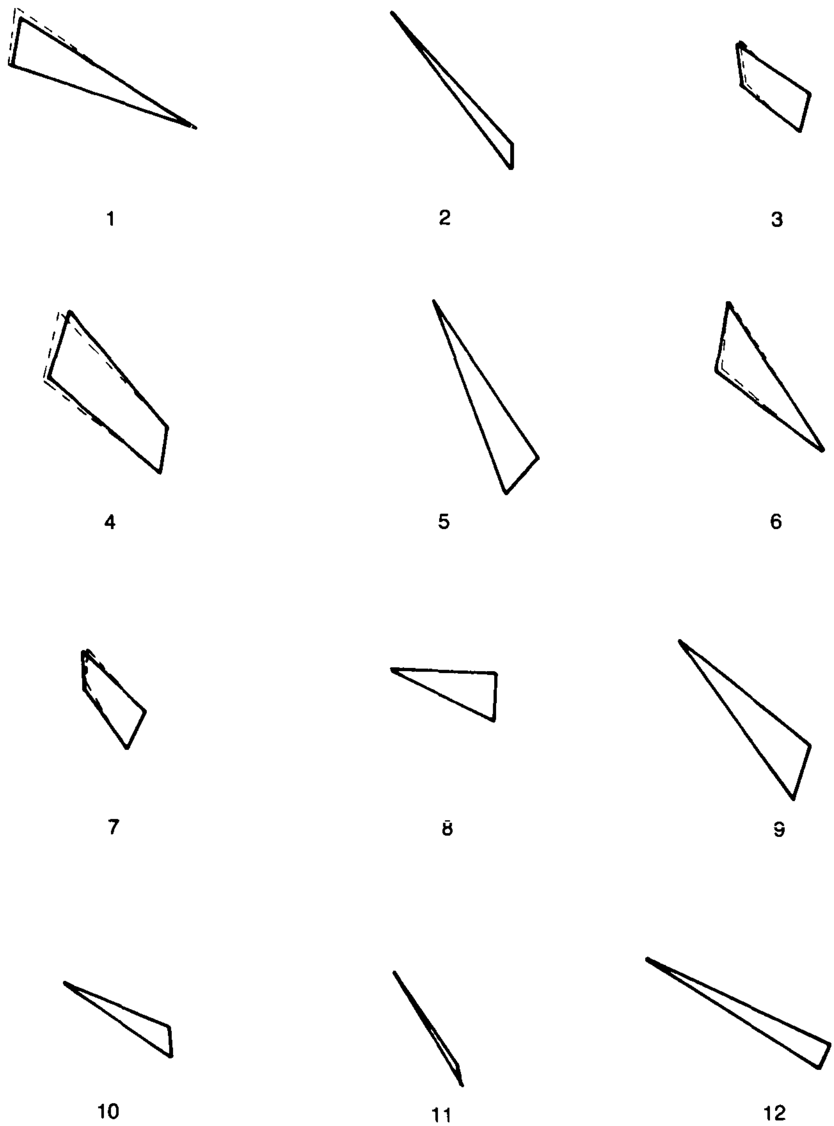


Fig. 6 **Superimpositions of the metallic implants at the osteotomy site. Dashed lines show changes.**

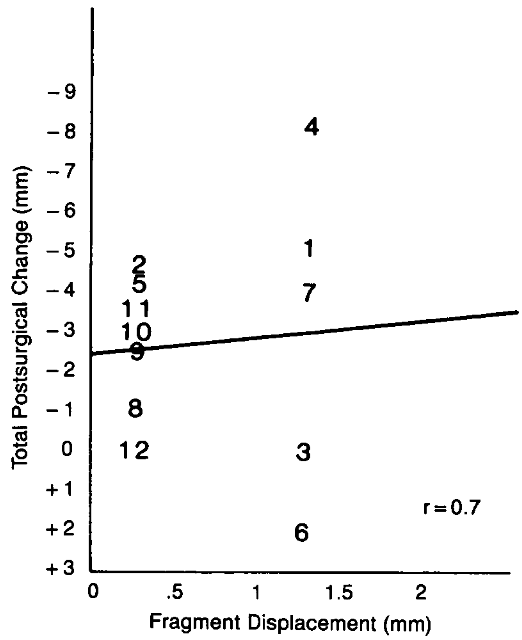


Fig. 7
Postsurgical horizontal change vs. fragment displacement. The low correlation (r=.07) indicates no significant relationship.

with p=.10, which does not reach the .05 level of significance.

The distance from pogonion to one of the anterior implants was measured to see whether there was any change in corpus length from regression of the genioplasty. There was no significant change in this dimension during the fixation period.

Distance across the surgical site on the left side was measured between the implant images, connected to form either a triangle or a quadrangle on films T-2, T-3, T-4, and T-5. Successive tracings could then be superimposed to detect any dimensional change at the osteotomy site.

The superimpositions are shown in Fig. 6. Seven cases showed no detectable change between T-1 and T-3, and 5 showed only very little change, with a range between 0 and 1mm (mean change was .42mm).

Testing for significance of this segment displacement against the total horizontal regression, the r value of .07 demonstrates no significant correlation or clinical significance in the changes at the osteotomy site over this interval (Fig. 7). These changes were well within the limits of measurement error, suggesting that other stabilization devices such as lag screws or metal plates are not required for adequate stability.

The last area tested for stability was condyle displacement. All five tracings for each patient were superimposed on

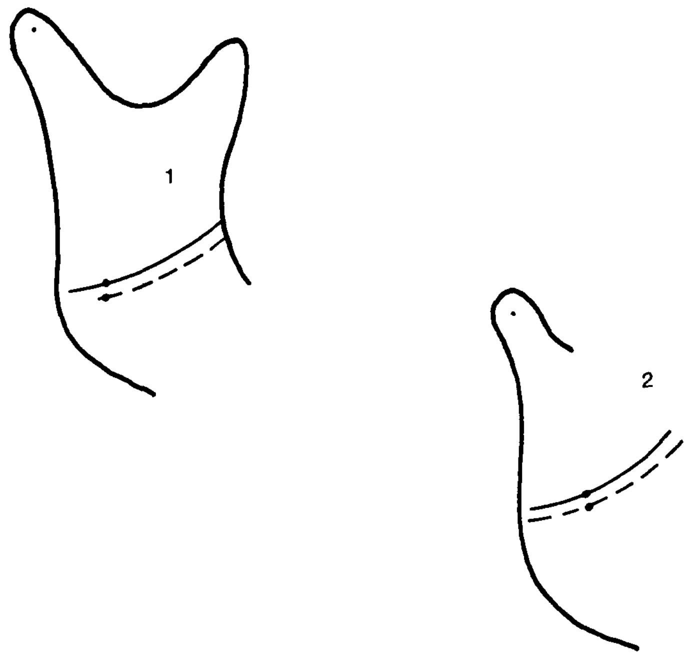


Fig. 8
Individual ramus superimpositions for cases 1-2. The solid arc is at T-1, the broken arc at T-2.

the cranial base triangle, Ba–S–N. A pinhole placed through the centers of the condyles provided a common reference point in that area.

The proximal segment on tracing T-2 was then superimposed over the same proximal portion of the ramus on tracing T-1, and the proximal implant outlines transferred to the original tracing. Arcs could then be scribed from the common reference point on the condyle to the proximal implants.

Arcs centered on the common reference point based on the original condyle center position could then be scribed through the proximal implants. Superimposing the tracings and registering on the condyle reference point, differences between the arcs could be noted (Figs. 8-10). When the arcs were superimposed and registered on the proximal implants, the difference between the condyle reference points and the direction of change could be traced (Fig. 11).

The displacement direction was always downward and usually forward, following the anatomy of the glenoid fossa. All but one case showed some evidence of *condyle sag* between T-1 and T-2. When the condyle displacement was plotted against the total horizontal regression, an r value of .65 was found. This is highly

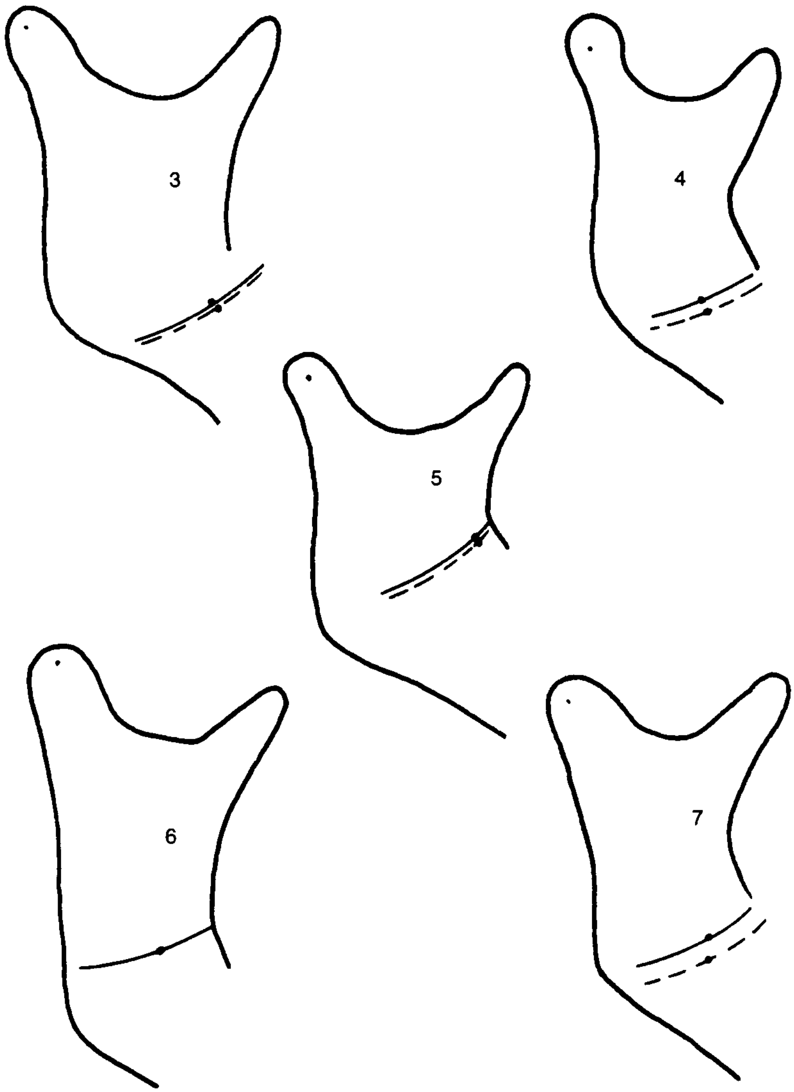


Fig. 9
Individual ramus superimpositions for cases 3-7. The solid arc is at T-1, the broken arc at T-2.

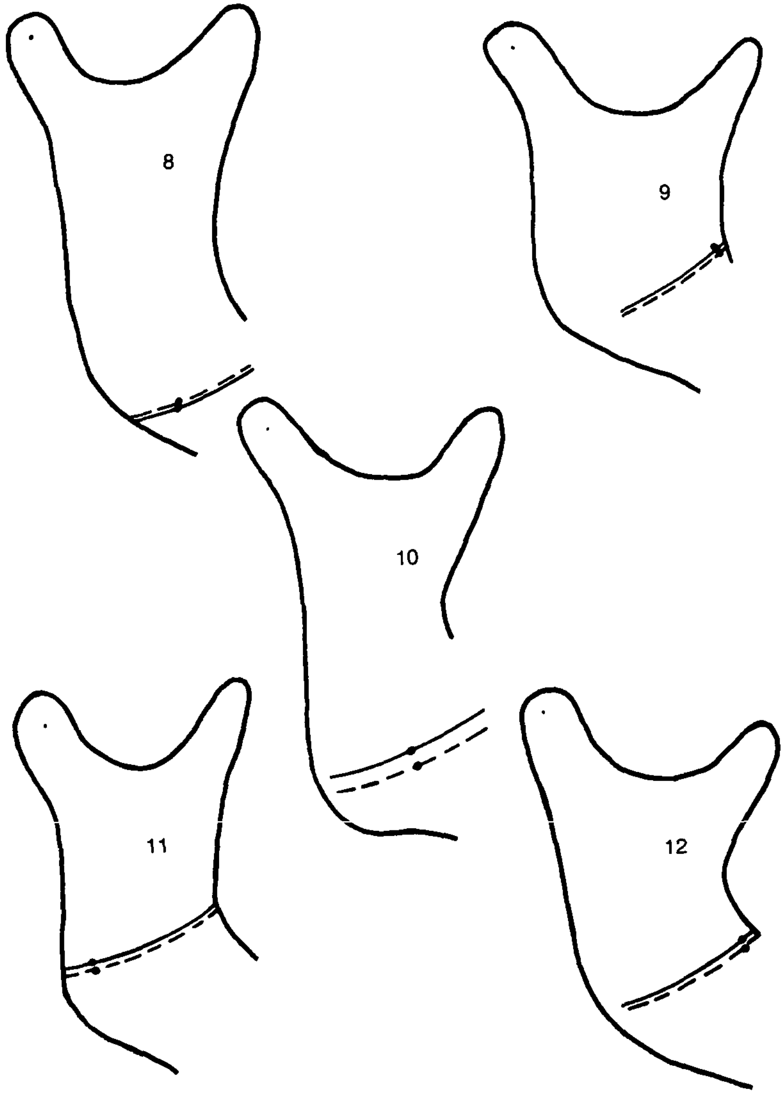


Fig. 10
Individual ramus superimpositions for cases 8-12. The solid arc is at T- 1, the broken arc at T-2.

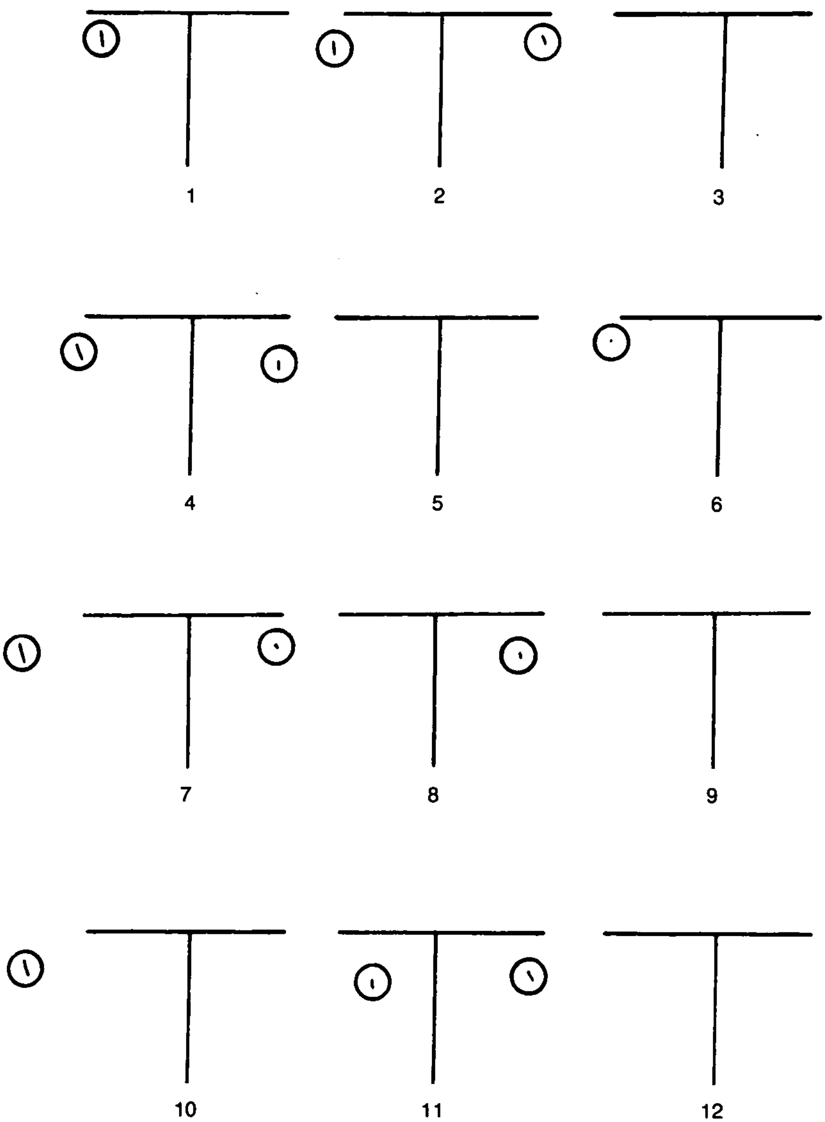


Fig. 11
Circled marks show the distance and direction of condyle displacement one day after surgery, between T-1 and T-2.

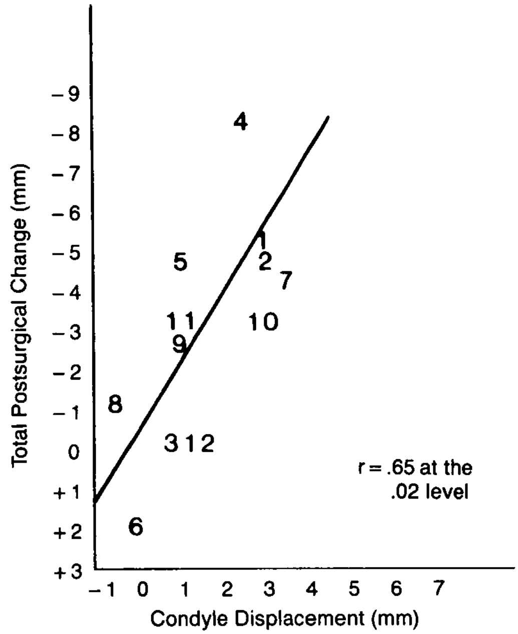


Fig. 12 **Postsurgical horizontal change vs. Condyle displacement. Negative values indicate regression.**

significant at the .02 level (Fig. 12). Of the three areas studied, the total regression was most highly correlated with the condyle displacement that occurred within the first day after surgery. This displacement ranged from −.5mm to +3.5mm (mean −1.66mm) (Table 1).

Since nasotracheal intubation at the time of surgery requires the use of a depolarizing agent such as succinylcholine chloride, it could be assumed that there should be some period of time that the muscles of mastication will be extremely flaccid. McMillen showed a mean 2.43mm drop of the condyles in the glenoid fossae under these conditions, and this could account for a major part of the condyle sag. The edema during the first 24–48 hours after surgery could also force an accommodation of the mandible downward and forward, both directly and as a functional adaptation for respiration.

The followup study at T-5, at least two years out of fixation, showed an additional 7% of horizontal regression, bringing the total mean regression to 27% (Table 1) (Figs. 13 and 14). This later regression appeared to be a physiologic muscular adaptation following the influence of surgery, orthodontic appliances, elastics, retainers, and some continued nasorespiratory difficulty.

Some of the cases showed a narrowing of the expanded maxillary width, which could contribute to a rotation of the mandible and additional regression.

Table 1

Sample Description and Data

Patient	Age at T-2	Sex	Wafer Y=Yes N=No	T-2 Horiz Postop	T-3 Horiz IMF	T-4 Horiz 6 mo	T-5 Horiz 2 yrs
1	19.206	♂	Yes	+14	−6	+1	−2
2	20.572	♀	No	+21.5	−4.5	0	+1
3	28.408	♀	No	+11	−2	+2	−3
4	20.942	♀	Yes	+15	−5	−3	0
5	23.745	♀	Yes	+17	−2.5	−2	+1
6	27.772	♂	Yes	+10	+2	0	+2
7	18.460	♂	Yes	+14	−4	0	−3
8	29.020	♂	Yes	+5	−1	0	−3
9	31.970	♀	No	+7	−2.5	0	
10	32.634	♂	Yes	+30	−4	+1	−3
11	25.326	♀	Yes	+17	−2	−1	−2
12	32.129	♀	Yes	+4	−1	+1	0
Min	18.460			+4	+2	+2	
Mean	25.848	7♀ 5♂	9Y 3N	+14.4	−3.1	−0.1	
Max	32.634			+30	−6	−3	
S Err				2.1	0.6	0.4	
S Dev				7.0	2.1	1.3	
Mean Regression					19%	1%	7%

Patient	Age at T-2	Sex	Total Horizontal	Proximal /Distal Movement	Condyle Change mm	Horizontal %
1	19.206	♂	−7	1	+3	−50%
2	20.572	♀	−3.5	0	+3	−16%
3	28.408	♀	−3	1	+1	−27%
4	20.942	♀	−8	1	+2.5	−53%
5	23.745	♀	−3.5	0	+1	−21%
6	27.772	♂	+4	1	0	+40%
7	18.460	♂	−7	1	+3.5	−50%
8	29.020	♂	−4	0	−0.5	−80%
9	31.970	♀	−2.5	0	+1	−36%
10	32.634	♂	−6	0	+3	−20%
11	25.326	♀	−5	0	+1	−29%
12	32.129	♀	0	0	+1.5	0%
Min	18.460		+4	0	−0.5	
Mean	25.848	7♀ 5♂	−3.9	0.4	+1.7	
Max	32.634		−8	1	+3.5	
S Err			0.8	0.1	0.4	
S Dev			2.6	0.5	1.2	
Mean Total Regression						27%

*Patient #9 was not included in the T-5 sample.
Patient #1, #9, and #12 had Class II deepbites, the others Class II openbites.
Patient #3 and #9 were operated by Dr. William Wallace, the others by Dr. Gary Racey.

Fig. 13
Case #2 before treatment. *(see Fig. 2 for lateral radiograph)*

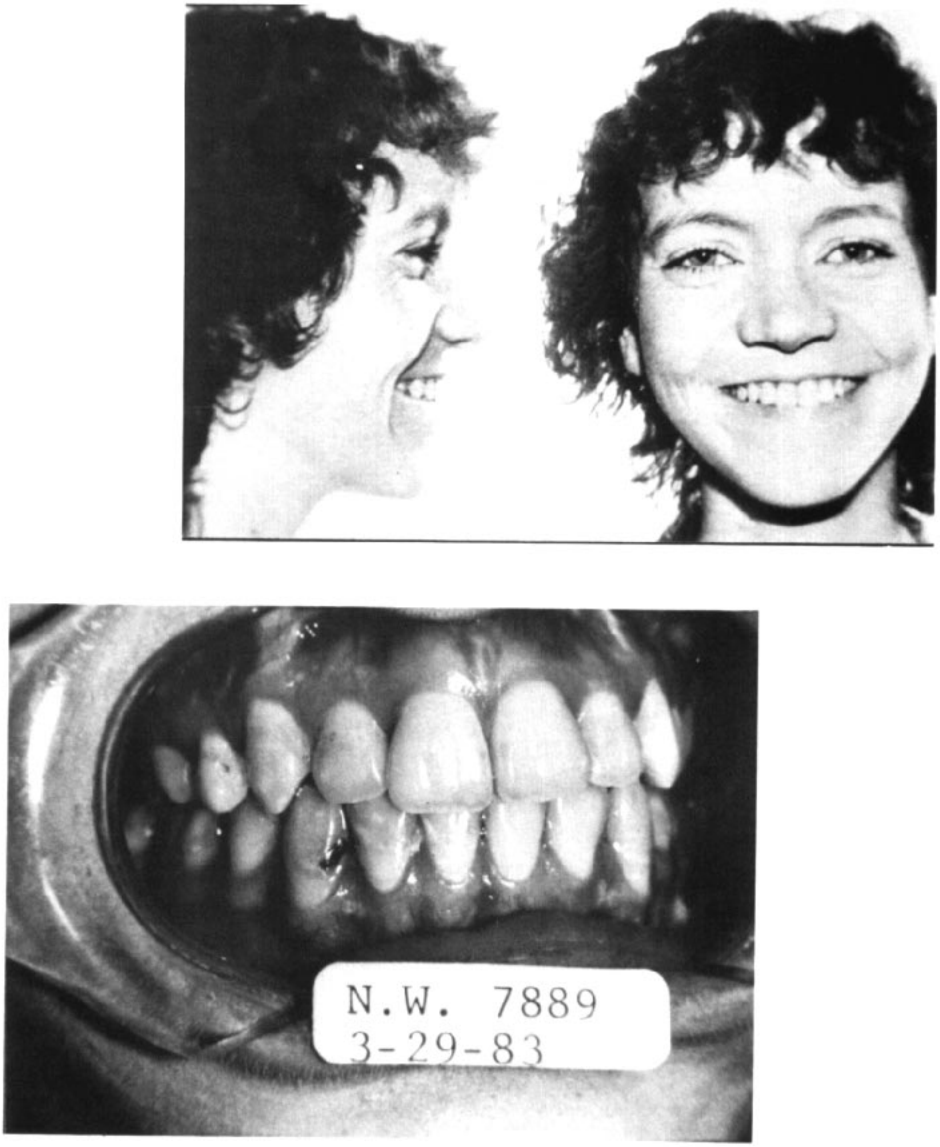


Fig. 14
Case #2 after orthodontic treatment and maxillary impaction, mandibular advancement, and genioplasty.

Dentition is shown out of retention. Her skeletal regression was 21%, and there was no noticeable movement between the proximal and distal segments.

— Conclusions —

The most definitive finding is that there is little if any change between the proximal and anterior segments during healing. A single fixation wire appears to be adequate in combination with dental fixation.

Condyle displacement at the time of surgery is a major factor in the regression following mandibular advancement.Practically all of the cases showed some condyle displacement one day after surgery. This could be due to a combination of the effects of edema from the surgery and a physiologic need to maintain a patent airway, surgical technique, and condyle sag from general anesthesia and muscle depolarization.

Most regression (mean 19% of the surgical correction) takes place before fixation is removed.

Two years after release from fixation, an additional horizontal regression of 7% was found (total mean regression 27%). This physiologic adaptation or rebound followed all biomechanical therapy, still leaving a mean 73% of the original improvement in mandibular length.

The sample is too small for definitive statistical evaluation, but there appears to be —

less regression of the mandible with two-jaw surgery than mandibular surgery alone, and —

some correlation between the amount of advancement and the amount of regression.

This paper is dedicated to the memory of Dr. Robert E. Wade.

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