Textbook of Oral and Maxillofacial Surgery

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Chapter 23

Developmental deformities of the jaws

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Developmental deformities of the jaws are those deformities that present malocclusion of the teeth, malrelation of the jaws, and associated facial disfigurement. They are thought of most often as congenital in origin, but they may also result from other causes.

The surgical correction of these deformities is one of the most challenging and intriguing aspects of oral surgery. Helping persons so afflicted is also one of the most gratifying services that it is possible to render.

Individuals with developmental deformities of the jaws are invariably self-conscious of their abnormal facies and usually have reflected personality problems. Their primary concern is their appearance. However, when correction of these deformities is contemplated, more than esthetic improvement must be considered. Correction of functional deficiencies is even more important, and this factor must be fully considered in treatment planning. In almost every instance personality inadequacies are eliminated automatically after corrective surgery.

For the sake of simplicity, deformities of the jaws will be discussed in their basic forms, namely, prognathism, micrognathia, and aperognathia. It must be understood that many variations do occur and that the primary deformity may be in the maxilla as well as in the mandible, or it may be coexistent in both jaws. A complete knowledge of surgical procedures applicable to the basic deformities should enable the oral surgeon to deal properly with all deformities.

Definition of terms applied to developmental deformities of the jaws is necessary for an understanding of the problem. *Prognathism* is defined as an abnormal projection forward of one or both jaws, whereas *micrognathia* is defined as a smallness of the jaws, especially the underjaw. *Apertognathia,* or open bite, is a condition in which space remains between the maxillary and the mandibular teeth when some teeth are in contact at one or more points. Various other malformations may occur as well, but they are usually variants of these three basic forms. Asymmetries are an example and will be discussed later in the chapter. Hypertrophies and agenesis will also be discussed.

One cannot be fully appreciative of the age in which we live today until one takes the time to read of the experiences of earlier surgeons who dealt with facial deformities. The details of case histories reported by pioneers in this field are truly fascinating to study. It is fortunate, indeed, that men such as Hullihen and Blair had the basic knowledge, imagination, and courage to attempt the surgery that they describe so vividly. Many of the original contributions in this field of corrective surgery are the basis for standard operations today.

Refinement in surgical technique, better understanding of physiology and anatomy, and the addition of modern methods of anesthesia and drug therapy have eliminated or minimized the hazards that were so great a few short years ago.

Hullihen can be credited with the first operation for correction of malrelation of the jaws. The patient he described in 1849 was 20 years of age and has been severely burned on the neck and lower part of the face 15 years earlier. The "cicatrix produced a deformity of the most dreadful character. Her head was drawn forward and downward with the chin confined to within an inch of the sternum. The underjaw was bowed slightly downward and elongated, particularly its upper portion, which made it project about one inch and three-eighths beyond the upper jaw." Hullihen studied his patient's problem and resolved it surgically by "sawing out" a V-shaped segment of bone from the upper "elongated portion three-fourths of the way through the jaw" and then completing the section forward horizontally, thus allowing "that portion of the jaw and teeth which before projected and inclined outward" to return to its "proper and original place".

Probably the most important early contributions came from Blair, who was a great philosopher and author as well as a great surgeon. In 1907 Blair wrote: "While surgeons for centuries have expended early talent and energy upon the correction of deformities of almost all kinds, from clubfoot to malrelation of the teeth, both for cosmetic and utilitarian reasons, yet little study or work seems to have been done to alleviate those distressing conditions that arise from excessive asymmetry of the dental arches. Where this deformity was too great to be corrected by orthodontic appliances, the victims have, so far as I can determine, with the exception of a few isolated cases, been compelled to go through life without relief." Furthermore, Blair recognized and classified facial deformities much in accordance with present-day concepts. He stated that "... the malrelation consisted either in a disproportionate growth in the length of the body of the lower jaw, in the lack of development of the upper jaw, in a lack of development of the lower jaw, (or) in a bending downward of the lower jaw at or in front of the angle..."

Typical of his optimism was the statement "We have to deal with an upper solid jaw and a lower one that is a hoop of bone *capable of almost any kind of adjustment,* and it is upon the latter that our efforts must be expanxed." He described ostectomies and osteotomies for correction of prognathism, open bite deformities, and micrognathia. He recognized "three distinct problems: (1) the cutting of the bone, (2) the placing of the jaw in its new position, and (3) holding it there." This classic paper was written 60 years ago but should be prescribed for reading and study today by anyone who contemplates performing surgery for correction of these deformities.

Articles and single case histories describing various operations for correction of these deformities appeared in the literature intermittently thereafter. Among them were many outstanding contributions. The difficulties were many until more recent years, and probably failures went unreported, whereas successful cases were well documented. Much of the difficulty encountered earlier was eliminated with the advent of antibiotics and the increased publicizing of cases and techniques. Refinements of certain techniques has led to their acceptance as standard procedure, the operative details of which will be discussed later.

In Europe the awakening to the possibilities for surgical correction of facial deformities began at the turn of the century. Bruhn of the West German Maxillo-Facial Clinic in Dusseldorf reported in 1927 on the increasing interest in developing new techniques, which was stimulated by the treatment of diseases and wounds of the jaws in Germany during World

War I. He stated: "Gradually a new sphere of medical and dental science aorse, and soon a new system became possible. Thus a new way was found to remove the deformation of the lower jaw, especially the so-called macrognathy and micrognathy." Unfortunately, this was one of the few significant exchanges of ideas or concepts prior to 1960 between American and European surgeons. The first and most obvious reason for this lack of exchange was the language differences. The translation of foreign scientific literature came as an outgrowth of the ever-widening communications among all nations after World War II. The wars were two-edges swords. They produced the need for the development of new methods of treatment, but they also interrupted the scientific intercourse that serves to embelish the production of scientific knowledge.

Whatever the reason, the significant concepts and procedures developed by European innovators of surgical technique for the correction of facial deformities were not known in the USA until the late 1960s. These outstanding surgeons include Bruhn, Ascher, Perthes (extraoral vertical osteotomy of the mandibular vertical ramus), Immenkamp (modifications of anterior maxillary osteotomy), Wassmund (anterior maxillary osteotomy and Le Forte I osteotomy), Wunderer (anterior maxillary osteotomy, palatal approach), Pichler (mandibular osteotomy), Trauner (mandibular osteotomy at the mandibular angle), Schuchardt (two-stage anterior maxillary osteotomy, posterior maxillary osteotomy, combination surgical-orthodontic horizontal maxillary osteotomy), Köle (augmentation genioplasty, modification of anterior mandibular osteotomy), and Obwegeser (augmentation genioplasty and sagittal osteotomy of the mandibular vertical ramus). These surgeons vigorously applied Blair's observation concerning surgery of the mandible to the development of surgical techniques for the maxilla.

Tessier has made recent significant contributions to maxillofacial surgery. He has improved Gillies original concept of the Le Forte III osteotomy. His newer techniques for surgical positioning of the orbits and the frontal lobe are unique and wonderfult to behold.

Growth and Orthodontics

Detailed experimental and clinical studies have been made of the growth of the mandible, and it is unnecessary in this chapter to go into a comprehensive review of this subject as it relates to deformities. Normal growth of the mandible occurs in two ways: (1) appositional at all its borders except the anterior border of the ramus and (2) epiphyseal-like growth of the condyles. No definite etiological factors account for prognathism. Although heredity and endocrines must influence the development of this deformity, it may be a result of the hyperactivity of the growth center in the mandibular condyle. Clinically, we have observed that practically all excessive prognathic development of the mandible has occurred someplace in the vertical ramus. This observation is based almost entirely on the preoperative relating of study models. Almost always the dental arches relate to a satisfactory degree, but occlusion may not be ideal.

Conversely, micrognathia is usually a result of an interference in the condylar growth center by systemic or local causes. Trauma at childbirth or during infancy or early childhood is the most commonly observed etiological factor. Growth interference may be unilateral or bilateral, resulting in asymmetrical or symmetrical deformity.

Prior to surgical correction of jaw deformities the surgeon must establish the fact that the condition is in a static state and that it is not the result of endocrine disturbances such as giantism and acromegaly resulting from pituitary dysfunction. Tumors and ordinary hypertrophy should be recognized in differential diagnosis also.

The most reliable indicator of the cessation of growth of the facial bones is the evaluation of cephalometric roentgenograms. If tracings from three successive cephalometric roentgenograms taken 6 months apart can be superimposed with less than a millimeter of variance, growth can be considered to have ceased.

Whether surgery should be adjunctive to orthodontics or vice versa is debatable. We have seen patients with extreme prognathism who were treated by orthodontics for 3 or 4 years with no benefit or retardation of the progressing deformity. We have also seen patients with prognathism who were treated surgically at an absurdly early age. Developmental deformities must be dealt with at a proper time, and the best interests of the patient are served if the oral surgeon, orthodontist, and speech therapist combine their knowledge on a cooperative basis. Surgical correction and orthodontics should not be undertaken in mandibular prognathism until maturity is reached and maximum growth is attained. Depending on conditions and the operation contemplated, micrognathic mandibles may be corrected surgically at younger ages. Open bite deformities should not be corrected surgically until a speech therapist has controlled tongue thrusting habits. It is sometimes difficult to come to an understanding with younger patients, or more especially the parents, because of the patient's personality problems. If, for psychological reasons, a compromise is agreed to and surgery is undertaken earlier than appropriate, parents must understand that a second operation may be necessary later. Obviously, a record of this advice should be made.

Selection of an Operative Procedure and Preoperative Planning

No specific operation is applicable to a given jaw deformity. Selection of the most appropriate procedure for correction of the problem is incumbent on the part of the surgeon. Simply because one prefers to operate by way of the extraoral route should not be a reason to exclude all intraoral operations and vice versa; however, if there is a choice, then one should select the operation in which one is most comfortable and able, providing that morbidity is no greater and prognosis is equal. With the wide selection of operations available to us today, maxillary, mandibular, intraoral, extraoral, segmental, interradicular, it is preposterous to believe that an inappropriate procedure would be selected - that a Le Forte I maxillary osteotomy would be done to correct a 4-mm retrusion or simply to log another case or that multiple corticotomy would be offered when conventional orthodontics alone would provide a better result with minimal or no chance for permanent harm to the patient. Anterior maxillary osteotomies have been done when, in fact, the mandible should have been elongated and vice versa, and, occasionally, when the deformity should have been corrected by rhinoplasty alone. As an example, too much dependence is placed on cephalometric analysis when simply *looking* at a facial profile is sometimes more helpful. Illustrations are shown in articles and case presentations meetings in which it is obvious that the wrong operation was employed for a given problem. This is especially noticeable in the current enthusiasm for maxillary surgery and the resultant questionable outcomes. One must depend on basic principles and especially adhere to the golden rule in selection of operative procedures.

A correct solution is available for each individual deformity problem, but it must be obtained by utilization of every diagnostic adjunct available. Adhering to a fixed preoperative "workup" such as the following will clearly indicate surgical methods adaptable to any case that may present

Roentgenographic survey. A complete dental roentgenographic survey or Panorex is necessary as a diagnostic procedure prior to surgery to (1) rule out a periapical or periodontal

pathological condition, the treatment of which might require mobilization of the jaw after surgery, and (2) aid in the determination of the stability of teeth in the supporting tissue and their ability to withstand the stresses of fixation devices and immobilization.

Study models. Study models of artificial stone are necessary for preoperative studies of occlusal relationship:

1. One set indicating the exact preoperative occlusion is desirable for life, should any question ever arise subsequent to surgery as to the improvement achieved.

2. One set is needed in cases in which preoperative adjustment of occlusion is indicated. When the lower complement of teeth is moved as a unit at the time of surgery, the new occlusion should be determined and well established preoperatively. Although this preoperative occlusal "equilibration" may or may not be necessary, it is an exceedingly important procedure when indicated. When the study models are occludedinto the desired relation, prematurities will be found, but they usually are not excessive, and minor occlusal adjustment will provide normal function. Occasionally orthodontics will be necessary after healing as an adjunctive measure for good functional occlusion.

Preoperative equilibration is accomplished by trimming one inclined plane on a single tooth on the study model at a time. The same degree of adjustment is done in the mouth on the same tooth. Equilibration is thus carried out from one tooth to another until a fairly stable occlusion has been secured on all teeth. Final definitive equilibration is accomplished when the jaws are mobilized after healing is completed. This equilibrated set of study models should be taken to the operating room to be used as a guide to the placement of occlusion when the surgical movement of the jaw is accomplished.

Ostectomy or osteotomy in the body of the mandible is rarely necessary; however, in the planning of ostectomy for correction of prognathism, measured sections of each side of the ridge are cut out on study models to determine occlusion and jaw relation. When intraoral segmental osteotomy or corticotomy is contemplated, definitive model surgery is essential.

All operations on the facial bones involving the dental occlusion must first be accomplished on planning models that are accurate representations of the teeth, the alveolar processes, the adjacent sulci, and the palate. The dental models should be mounted on an articulator in centric jaw relation. The planning of operations on models mounted in the patient's convenience bite is fraught with problems and errors. Planning is most easily and accurately accomplished when the models are mounted on an articulator, which allows for the sectioning and movement of segments of the dental apparatus while the bases remain stationary.

Invaluable information is gained from properly executed model operations. The operation or operations that best suit the needs of the case are determined, the direction and degree of movement of segments is established, and the advisability of the use of orthodontic movement preoperatively or postoperative is ascertained. Accurate operative guide stents and postoperative immobilization splints are constructed on the section models.

Cephalometry. *Direct lateral skull roentgenograms (cephalograms),* including the mandible, are essential for preoperative evaluation in all patients regardless of the type of deformity. Cephalometry, primarily utilized in the study of craniofacial growth and orthodontic analysis, is most helpful in the determination of the precise location of jaw

deformities and in selection of proper operative sites for surgical correction. The practical application and value of cephalometric techniques are well documented; however, these studies are adjunctive and must be correlated with clinical observations to arrive at a proper conclusion.

The application of cephalometry to the problems inherent in ortodontic surgery provides information that is indispensible. Oral surgeons recognize that early efforts toward the standardization of measurements of the craniofacial osseous structures made by anthropologists such as Krogman and orthodontists such as Angle, Schwartz, Tweed, Sassouni, Reidel, Downs and Steiner, and the later works of Taylor and Hitchcock provided a means of continuing evaluation of treatment from the preoperative through the postoperative periods.

Portions of each analysis recommended by these investigators have direct application on the evaluation of surgical treatment of developmental deformities. When cephalometric measurements are selected relative to their ability to evaluate the preoperative configuration and postoperative position of the gnathodental complex, numerous measurements useful to the orthodontist are recognized as irrelevant to the surgeon. Thus a method of cephalometric analysis universally applicable to the evaluation of the case treated primarily by surgery has been selected by each surgeon. The most reliable and most universally used is the angle SNA formed at nasion by the intersection of the line drawn from the midpoint of the sella turcica concavity (S) to nasion (N), or the sella-nasion line, and the line drawn from the subspinale (A), which is the point of greatest concavity of the anterior portion of the maxilla. A second similar angle SNB is formed at nasion by the intersection of the sella-nasion line (SN) and a line from the supramentale (B), which is the point of greatest depression of the anterior portion of the mandible. The angle formed at nasion by the line from subspinale (A) to nasion (N) and the one form supramentale (B) to nasion (N) is called the *ANB difference.* SNA and SNB relate the maxilla and the mandible to the cranial base. The ANB difference relates the anterior maxilla to the anterior mandible. The mean for SNA is 82 degrees and that for SNB is 80 degrees, making the ANB difference 2 degrees. The gonial angle is formed at the angle of the mandible by the intersection of the mandibular plane (line through gonion and gnathion) and a line tangent to the posterior border of the vertical ramus of the mandible, which is tangent at the most posterior point near the angle and the most posterior point of the mandibular condyle. The mean of this angle is 125 degrees. The angles of inclination of the most anterior maxillary and mandibular incisor teeth establish the degree of procumbency or recumbency of each. The inclination of the mandibular incisor is related to the mandibular plane. Normal incilination is 93 degrees. The maxillary incisor is related to the sella-nasion line. Normal value for this measurement is 104 degrees. Schwartz recognized that although skeletal measurements have relevance to the clinician, the soft tissue covering is what the patient, his family, and his associates see. He developed an analysis that combined the measurement of the relationship of bony landmarks with evaluation of the configuration of the soft tissue covering. His analysis used the Frankfort horizontal line as its base. Perpendicular lines to the Frankfort horizontal line were drawn from a point on the skin overlying nasion, and a second line was drawn from a point on the skin overlying the most inferior point on the infraorbital rim, which was also in line with the pupil of the eye. The infraorbital point was transferred to the cephalometric roentgenogram by fastening a piece of lead shot to the skin in the desired position. Schwartz then classified facial profiles according to the position of the soft tissue chin prominence. He further subdivided the patients classified into those whose palatal plane (this is, anterior nasal spine joined to posterior nasal spine, or ANS-PNS) made an angle of 85 degrees with the soft tissue-nasion line, those with less than 85 degrees at this angle, and those with more than 85 degrees. Within these three groups, he

divided his patients into those with average profiles, those with forward profiles, and those with retruded profiles. He believed that the male profile, whatever the classification, should have a more forward position of the chin than the female's. Further improvements on Schwartz's analysis by adding information more relevant to the surgeon are being developed by Obwegeser and Gerhard.

McNeill and co-workers have recently published a cephalometric means of predicting the postoperative profile. They make use of the representation of the soft tissue profile line as reproduced on the roentgenograph by placing radiopaque media on the midline of the face.

The recognition of the basic principles in treatment planning as proposed by Obwegeser indicates the need for more than a practiced eye and the positioning of dental models. He stated that an esthetically pleasing and correctly functioning gnathic apparatus is obtained by the correct positioning of maxillary and mandibular basilar bone, the adjustment of the inclination of the anterior teeth to the basilar bone, and the establishment of the best available dental occlusion.

Recently the scope of possibilities for the surgical correction of facial deformities has expanded greatly. This is partially because of the increased means of preoperative and postoperative evaluation of surgical procedures.

Additional extraoral roentgenographic procedure. If a cephalometer is not available, a lateral skull roentgenogram properly made will suffice for evaluation. For this projection a 5-foot target to film distance is recommended, using a technique of 300 milliamperes, 70 kilovolts, and 1/12-second exposure. The central ray should be directed at absolute right angles to the mid-sagittal plane through the mandible at the gonial angle. As the exposure is made, the patient should be instructed to take his teeth out of occlusion just enough so that mandibular and maxillary occlusal planes are not superimposed. One exposure should also be made with the teeth in occlusion so that true degree of retrusion, protrusion, or open bite can be measured.

Preoperative template studies. With the use of tracing paper, the skeletal profile of the mandible and maxilla is traced. Superimposition of one side onto the other makes accurate definition of the occlusal surfaces of the teeth impossible. The occlusal planes can be followed when one roentgenogram has been made with the jaw in rest position. Location of the mandibular and mental foramina and the mandibular canal should be recorded on the tracing also.

This profile tracing is then transferred with carbon paper to thin cardboard (manila letter file holder), and the resulting outline is then cut out, thus producing cardboard templates. From these templates, trial sections can be made until a desirable location for osteotomoy or ostectomy is found. The cut sections of the template of the mandible are then fitted back to the tracing in the desired occlusal relation. The section containing the condyle is overlaid in this precise "preoperative" position, whereas the other section is "occluded" and otherwise adapted for the study. This is a helpful and enlightening diagnostic procedure.

Measurements. The amount of protrusion measured in millimeters in prognathic mandibles is not necessarily indicative of the amount of correction necessary. Measurements vary. Occasionally the degree of Class III malocclusion measured in the first molar region will be unequal bilaterally. This measurement cannot be correlated exactly to the incisal edge discrepancy. Therefore, measurements should be standardized in every clinic. In our practice

the amount of protrusion is calculated from the incisal edge of lower central incisors to a point lingual to the maxillary incisors where ideal incisal relation is estimated to be.

Preparation of the Patient for Surgery

Routine procedures and miscellaneous preparations. Routine procedures required for any patient undergoing general anesthesia and major surgery should be accomplished the day prior to surgery.

A number of other preparations are considered to be essential in these cases. These are as follows:

1. *Shave and skin preparations.* Most male patients are instructed to shave closely the night before surgery. Those with heavy beards should shave early the morning of surgery. Male patients should shave to the level of the zygomatic arch.

Female patients are instructed to put their hair up in "curlers" or braids the night before surgery so that it can be easily controlled under the drapes.

All patients are ordered to take "lather" showers and shampoos with antiseptic surgical soap the night before surgery. Their instructions are to lather from head to toe out of the shower for 5 minutes (by the clock), rinse, relather for 5 minutes, rinse, and dry.

2. *Antibiotics.* Antibiotics are optional and are ordered only on specific indication or at the discretion and judgment of the surgeon in charge of the case. However, this protection should be routine in all intraoral operations.

3. *Fixation appliances.* Fixation appliances should be placed prior to the day of surgery since most of the corrective surgical procedures are time consuming and anything that can be accomplished ahead of time should be. If orthodontics is to be done adjunctive to surgery, it is good planning to have the necessary appliances in place prior to surgery and utilize them during the period of immobilization.

4. *Oral hygiene.* Prophylaxis should be accomplished if indicated. Any inflammatory condition of the gingiva or oral mucous membranes should be treated and eliminated, especially including pericoronal infections involving erupting third molars and especially prior to intraoral operations.

5. *Mental preparations.* Although the patient will have been psychologically prepared in the preceding weeks of workup as well as advised of the potential morbidity associated with the particular operation planned, there are additional details of the surgery that, if explained on the eve of surgery, will make the immediate postoperative period much smoother for both the patient and the surgeon. In our experience, patients - young or old - appreciate being informed in detail of what to expect. When they first contemplate surgery, they inquire about scarring, length of the operation, number of days hospitalized, how they will eat, and so on - all of which is carefully explained; however, equally important are the answers to questions that they have not thought to ask. Since we have our patients in the office for a final check, placement of fixation appliances, and other preliminaries just prior to admission, we find this to be a convenient time to review hospital routines. Members of the family are with the patient, and this visit is helpful to them also. This review is important since many

patients have never been hospitalized and are unfamiliar with the real thing. In addition to information already covered, we tell the patient in terms he can understand:

a. The he will "go to sleep" because of "medicine" given through a "needle in a vein", that the needle will still be in place when he awakens after the operation, and that it will remain overnight and why.

b. That a "small tube" will be passed through the nose into the "windpipe" after he is asleep and why and that as a result, he may experience a sore nose and throat for 2 or 3 days after the operation.

c. That his head will be fully bandaged when he awakens, with only the face exposed, and that this bandage will be kept in place for 4 to 5 days. (Some patients or parents are concerned by large dressings.)

d. That his jaws will be held together with elastic bands when he awakens, especially that it is important not to fight this restraint, and that the elastics can be removed easily and quickly in case of need.

e. That because of the use of modern anesthetic agents and routine administration of other preventative drugs occurrence of postoperative nausea is uncommon.

f. That postoperative pain is not great as a rule and, although pain control medicines will be ordered, that requests for them should be on a real need basis, thus further helping to prevent nausea.

g. That he will be kept in "overnight recovery" or "intensive care" routinely through the first postoperative day and night and why this precaution is taken.

h. That the presence of generalized muscle ache, fatigue, and occasional headache following general anesthesia is common but transitory and why they occur.

We have found that communication with patients in anticipation is most helpful to their general well-being. Language they can understand is desirable, with use of technical terms kept to a minimum.

Anesthesia

Choice of an anesthetic is a matter for consideration by both the surgeon and the anesthesiologist. The latter must thoroughly understand the problems related to surgery about the jaws and the need for protection of the airway during the recovery period. The selection of anesthetic agents should take into account the possibility of nausea and related complications that may develop while the jaws are immobilized.

Nasoendotracheal intubation is routine, and the airway is maintained until the patient has reacted from the anesthetic. The stomach is partly emptied by suction at the conclusion of surgery using a nasogastric tube, thus controlling the incidence of vomiting in most cases.

Skin preparation and draping

For extraoral operations the patient should be placed in a supine position on the operating table with his head well extended. After he is intubated and asleep, a Turkish towel is placed under his shoulders, which permits further extension of the head and makes the submandibular area accessible to light and surgery.

The anesthesiologist should be placed at the head of the table to permit direct access to the airway and thus good control of the anesthetic. At the same time the surgical team has ample access to both sides of the patient.

An antiseptic surgical soap is routinely used in preparation of the skin of the operative field. A wide area of skin is lathered for 10 minutes and then blotted dry with a sterile towel. The preparation is started in the immediate area of the incision and circled outward to the perimeter.

Proper draping of the patient for extraoral operations is exceedingly important in maintaining a clean surgical field, preventing postsurgical infection and saving operative time. Step procedure recommended is as follows:

1. A towel and folded sheet arrangement is utilized to drape the head. Both are carried across the table under the patient's head as it is raised by the anesthesiologist or a circulator, care being exercised that the scrubbed area of the face is not contaminated.

2. The head towel is secured under the nasoendotracheal tube with Backhaus towel forceps.

3. Another towel is draped over the head towel with the folded edge carried across the upper lip and over the endotracheal tube. It is secured to the head towel on both sides with towel forceps.

4. The entire body is covered with a split sheet extended past the head on both sides.

5. A single towel is then placed on each side over the patient's neck, with the folded edge about 2 inches below the lower border of the mandible and parallel to it on each side. These two towels are clipped together as they cross at the midline above the sternum as well as to the head towels on each side. All towels are sutured to the skin with No 4-0 silk at intervals of 1.5 inches.

6. A drape sheet is then placed over the patient's head, secured to the head towels with towel forceps and to IV standards on each side of the table, thus "draping out" the anesthesiologist.

7. One more towel is now placed across the patient's mouth with the folded edge just below the lower lip and the towel draped toward the head, thus "draping out" the mouth. It is also secured on each side with towel forceps and to the skin with sutures at intervals of about 3 cm. It should be sutured to the skin just below the lower lip so that the whole chin is exposed, permitting visualization of areas innervated by the mandibular branch of the facial nerve. Thus as the nerve is stimulated during surgery, it can be identified. This last towel drape is an important one and a timesaver. It protects the extraoral surgical field from oral contamination during surgery and yet provides access to the oral cavity, since it can be turned

down over the surgical wound. Thus after occlusion adjustment and fixation of the appliances, the surgeon's gloves are changed, this adjustable "curtain" drape is replaced over the mouth, and surgery is continued.

Suturing the drapes to the skin at the periphery of the surgical field is important, since the patient's head must be moved from side to side during the surgery. Unless so secured the drapes tend to shift and loosen, with contamination sure to occur.

A variation in draping is utilized for intraoral operations. A low-profile anesthesia apparatus permits positioning of the anesthesiologist at the side of the table so that the surgeon may operate from the head of the table if desired. The procedure otherwise is very much the same as already described except that the oral cavity is thoroughly cleansed. The oral pharynx is packed, and the head is flexed somewhat instead of extended as in extraoral operations.

Technique of Soft Tissue Surgery

The standard technique for exposing the inferior border of the mandible through the soft tissue is used (see Chapter 2). However, to ensure success, certain parts of the technique are worthy of emphasis, since the ease with which bone surgery is accomplished is directly dependent on adequate access. This is especially true in access to the ramus.

Location of the incision must be given careful attention to be sure that deeper anatomical structures come to view in proper relation. Positioning of the patient can alter the relation of the incision to the lower border of the mandible as much as an inch. The proposed incision lines should be identified with a marking pen. The patient's head should be centered and not extended so that both sides can be marked symmetrically and the incision lines can be made in proper relation to the lower border of the mandible. Landmarks such as the gonial angle and the mandibular notch are then palpated and dye marks made on the skin, identifying their location. In locating the incision line for surgery to correct prognathism, it must be remembered that an obtuse gonial angle is characteristic and a part of the deformity. Also to be remembered is that when it is corrected, ideally, a more pronouonced angle should be developed. This being the case, it is often desirable to have the incision line somewhat lower than normal toward its posterior aspect for a good esthetic result. It should also be kept in mind that with the patient relaxed under anesthesia, the mouth may hang open several centimeters, resulting in a changed relation of skin to border of mandible. Therefore the mandible should be held in a closed, occluded position as incision lines are located.

Incisions for intraoral surgery require the same care in planning and execution. The surgeon must project this thinking toward the closure of the incision before the tissue is incised. Wound margins must be placed so as to not coincide with planned underlying bony cuts. A knowledge of the precise anatomy of any area being treated is mandatory to ensure the most favorable blood supply to flaps generated during the surgery. One must always keep in mind the fact that vigorous retraction to provide better observation of the surgical site may displace the soft tissue sufficiently to cause an incision placed over familiar landmarks to be grossly displaced. Suturing of flap margins to attached gingiva or through the embrasures between teeth is extremely difficult. Gingival tissues are thin and friable. Therefore paragingival incisions, those well into the movable mucosa of the mouth, are preferred to those placed in the gingival sulcus. The surgeon must plan sufficiently ahead to place sutures for closure before splints with wide coverages of soft tissue are wired into position.

Prognathism (Mandibular)

Significant progress in the field of surgery for treatment of prognathism has occurred since the first edition of this textbook. Notable contributions in the literature indicate a marked trend to surgery in the ramus in preference to the body of the mandible for correction of prognathism. Basic operations commonly employed in recent years include (1) subcondylar (or oblique) osteotomy in the ramus, (2) modification of the earlier horizontal osteotomy by intraoral sagittal splitting according to Obwegeser and its modification by Dal Pont, and (3) vertical osteotomy in the ramus. Osteotomy through the neck or at the base of the condyle and ostectomy in the body of the mandible are rarely indicated or utilized. (Osteotomy is the surgical cutting of bone, whereas ostectomy is the excision of a bone or a portion of a bone.) Operations in standard locations will be discussed in detail in the following text. Four of the procedures to be discussed employ the principle of repositioning the entire body of the mandible. The body of the mandible itself is shortened in the ostectomy. Osteotomy through the neck of the condyle has never attained general acceptance but is still used by a few oral surgeons. Subcondylar (oblique) osteotomies below the neck of the condyle are quite widely used now. Definition of osteotomy by direction, that is, oblique, vertical, or horizontal, is difficult; for example, an "oblique" subcondylar osteotomy in which the section is carried to a low point on the posterior border of the ascending ramus may well be in a vertical direction. The term *oblique* osteotomy as used in this text originally included all subcondylar osteotomies or those below the condyle head extending from the sigmoid notch to the posterior aspect of the ramus. For the sake of clarity and definition, ramus operations to be described herein will be referred to as (1) osteotomy in the condylar neck, (2) subcondylar osteotomy (oblique and below the neck or base of the condyle), and (3) vertical osteotomy to the gonial angle or anterior to it.

There are few indications for ostectomy in the body of the mandible, since a disparity between the mandibular and maxillary arches is rare. Only 1.5% of our patients required procedures involving ostectomy in the body of the mandible. Hinds found only one out of 20 patients for whom ostectomy in the mandibular body was indicated. Mohnac states "In my series of more than 100 cases, I have rarely found a Class III malocclusion in which the tooth-bearing alveolar region of the mandible was not in proportion with that in the maxilla". Improved surgical techniques and a broader knowledge of operative procedures have also led to greater use of ramus procedures, which are not at all formidable after 25 years of use.

Osteotomy in the condylar neck

Osteotomy in the condylar neck is most commonly accomplished by utilizing the Gigli saw in a "blind" section. It may also be performed through a preauricular incision, a Risdon incision, or by an intraoral approach. The objective is surgical section of the neck of the condyle, creating bilateral surgical fractures, with repositioning of the whole mandible to normal occlusal and jaw relation. In rare instances bony union may not occur or even may not be expected, but a satisfactory functional pseudoarthrosis is hoped for.

History of this condyle site for osteotomy dates back to 1898, when Jaboulay and Berard reported destroying the condyle "piece by piece", "with the aid of gouge tooth-forceps" by way of a preauricular incision. Duformental in 1921 also advocated condylectomy as a means of correcting "a protruded lower jaw". Pettit and Walrath in 1932 were the first to suggest osteotomy through the neck of the condyle. Their "bow back" operation was based on the principle of interposing temporal fascia and the creation of a pseudoarthrosis or flail

joint, which had been a standard arthroplastic procedure in treatment of temporomandibular joint ankylosis.

The first refinement to operations in this site came in 1940 when Smith and Johnson suggested the removal of a "parallel-epipedonal" section of bone from the region below the sigmoid notch. This was followed by horizontal osteotomy from that point posteriorly below the neck of the condyle to permit posterior repositioning of the mandible. Subsequently, Smith and Robinson reported 57 cases in which the patients were treated successfully by this sigmoid notch ostectomy.

"Subsigmoid" notch ostectomy and condylotomy suggested by Smith and associates offered few advantages over the blind osteotomy in the condylar neck. The method was never popular because of the surgical anatomy involved and the technical difficulties of the operation. In any open surgical procedure through a preauricular incision, the hazards of injury to the facial nerve are almost as great as by the blind Gigli saw method. The delicate excision of a measured section of bone from the subsigmoid notch area, as suggested by Smith, is a tedious procedure to contemplate because the depth of the wound is great and retraction of adjacent tissues must be limited.

In 1955 at the Los Angeles meeting of the Americal Society of Oral Surgeons, Moose suggested osteotomy at the neck of the condyle by an intraoral approach similar to that used for the intraoral sagittal splitting procedure. He recommended establishing an incision line in the bone with drill penetrations, followed by surgical fracture with chisel and mallet. One of use (JBC) assisted with one such operation on a patient with only 7 mm of protrusion. Healing occurred in 6 weeks, and a good result was obtained. Moose reports favorable results using this method in the correction of prognathism in 14 patients. In several other operations he found it impossible to adequately visualize the ascending ramus at a proper height for subcondylar osteotomy and resorted to the "ramus bisection" operation (horizontal osteotomy in the mandibular ramus above the mandibular foramen). This procedure is not recommended because of this experience plus other obvious disadvantages.

Reiter was one of the foremost proponents of operations in this region of the condyle and is said to have performed more than 75 such operations, but no published reports are available as to the successful results in his cases. He used a "blind" Gigli saw technique originally suggested by Kostecka for correction of open bite and performed by Schaefer for correction of prognathism. Verne and co-workers, studied 52 cases in which essentially the same techniques were employed. Their published results are impressive.

Technique for blind Gigli saw condylotomy. The technique for blind Gigli saw condylotomy is included for the sake of completeness only. The steps are as follows:

1. An incision approximately 1 cm in length is made through the skin at the posterior border of the ramus, somewhat below the base of the condylar neck, or about halfway between the lobe of the ear and the angle of the mandible.

2. The bone is reached by blunt dissection to prevent injury to the facial nerve or its branches.

3. A curved aneurysm needle is then passed in constant contact with the medial surface of the ramus below the neck of the condyle in an angular direction upward and obliquely forward until it slides out over the sigmoid notch.

4. As the skin is elevated by the emergence of the needle over the sigmoid notch, another short incision is made to permit exit.

5. At this point the Gigli saw is attached to the needle and carried through the tissues to position for the osteotomy.

6. It is recommended that "funnellike" cannulas be placed into both wounds with the wire saw passed through them for protection of vital soft tissue components

7. With osteotomy completed and the saw removed, one or two sutures are placed in both incisions to close the skin.

8. The mandible is reposition to the desired occlusal relationship, and intermaxillary fixation is applied to previously placed arch bars.

Advantages

1. The operation is a simple one to perform.

2. The operating time is short (30 to 60 minutes).

3. It has been done as a clinic or office procedure, although this is not recommended.

4. Instruments required for the operation are available commercially.

5. Fixation appliances need not be elaborate, since immobilization should not require more than 6 to 8 weeks.

6. External scarring is negligible.

7. Teeth need not be sacrificed, and edentulous alveolar ridge area for future denture coverage is not lost.

8. Injury to the mandibular nerve is not likely.

Disadvantages

1. A blind procedure in this area carries the hazards of:

a. Injury to branches of the facial nerve, with permanent facial paralysis, is a possibility.

b. Deep hemorrhage resulting from severance of the maxillary artery, one of its larger branches, or the posterior facial vein.

c. Injury to the parotid gland or its capsule and formation of a salivary fistula.

2. Lack of control of fragments occasionally results in a nonunion with "flail" joint.

3. Open bite is a distinct possibility that increases with every millimeter of correction beyon 10 to 12 mm. This is caused largely by the strong bipennate temporal muscle, which

prohibits posterior movement of the coronoid process more than about 10 mm, but also the vertical contracting action of the masster and medial pterygoid muscles produces a shortening of the vertical ramus resulting in the tendency to open bite anteriorly.

Based on this last disadvantage, the Gigli saw condylotomy operation is not accepted for general use and is not suitable for patients with more than a moderate degree of prognathism. Kaplan and Spring reported seven occurrences of gustatory hyperhidrosis associated with subcondylar osteotomy in 14 patients. They admonish the surgeon to understand and recognize the phenomenon as a relatively frequent complication. It is related to the misdirected regeneration of cut secretory and vasodilator fibers of branches of the auriculotemporal nerve, which results in postoperative sweating and flush of the skin during mastication.

Extraoral vertical osteotomy in the rami

Vertical osteotomy in the rami for correction of prognathism as it is usually accomplished is an extraoral operation through a submandibular approach. The objective is vertical sectioning of the ramus in a line from the lower aspect of the mandibular notch vertically downward over the mandibular foramen or just posterior to it to the lower border of the mandible at the angle. By decortication of a portion of the distal fragment (ramus, anterior to the vertical section), overlapping of the proximal fragment, and thus creation of a mortised overlay, the whole body of the mandible is repositioned posteriorly to a normal occlusal and jaw relation. It is an operation that is ideally suited to correction of extreme prognathism, which is anything in excess of 10 to 12 mm, and produces excellent results in fully or partially edentulous patients. Details of this operations were described by Caldwell and Letterman in 1954. A follow-up study of the original cases was made in 1965, 10 years after surgery. Functional and cosmetic results were excellent at that later date. We had used the procedure since 1952 and had operated on eight extreme deformities when the original article reporting three cases was finally published. In 1954 this operation was also recommended for selected patients in military facilities since it had been established that healing time was short and need for immobilization did not ordinarily exceed 4 weeks. We have performed this surgery for approximately 650 patients, with generally excellent results. The Walter Reed Army Hospital group while under Shira's direction also operated on a large number of patients using this method with equally successful results.

Technique for extraoral vertical osteotomy in the rami. Certain modifications and improvements have been made in the technical procedure of vertical osteotomy since it was first reported in 1954.

1. Soft tissue surgery has been described previously. It is done through an incision approximately 3 to 4 cm in length.

2. The lateral aspect of the ramus is exposed to the mandibular notch. Muscle attachments on the medial aspect of the ramus are not disturbed at this time.

3. The prominence overlying the mandibular foramen is identified.

4. A vertical line for bone incision is planned from the lowest point of the mandibular notch to the lower border of the mandible at the angle passing over the prominence of the mandibular foramen or slightly posterior to it. This line may be lightly scribed onto the

surface of the bone with a #703 carbide bur before cuts are actually made to be sure the line of osteotomy is correct.

5. exposure is ample, with the second assistant elevating and protecting the soft tissue with Army-navy retractors and Thompson ramus retractors H135R and L.

6. A No 703 taper fissure carbide bur in a straight handpiece powered by a Jordan-Day or Emesco autoclavable explosion-proof engine is used to make the initial vertical cut in the lateral cortical plate. Either of these pulley-driven handpieces provides more torque than is experienced with higher speed air drills, resulting in a more exquisite sense of touch, which permits more intricate and precise cuts in the critical points of osteotomy. Either engine runs at about 18.000 rpm, ample speed for safe, accurate bone cutting.

7. The first assistant maintains a constant flow of water on the bone as cuts are made, aspirating at the same time to prevent soaking the drapes.

8. The initial cut is made carefully over the area of the foramen to avoid complete penetration of the lateral cortex, thus avoiding injury to the nerve as it enters the bone.

9. The coronoid process is sectioned if indicated. It may be left undisturbed in less pronounced protrusion, but if a correction of more than 8 to 10 mm is anticipated, coronoidotomy is advisable to obtain unrestricted movement of the jaw posteriorly. In fact the procedure is so simple and completely free of contraindications that it is done almost routinely. (See section on relationship of musculature to surgical correction of jaw deformities.)

10. Sectioning the coronoid is simple. Closely spaced drill penetrations are made obliquely from the sigmoid notch to the anterior border of the ramus using a No 14 bone drill. The medullary space is usually absent or imperceptible here, so as soon as the high-speed bur no longer meets resistance, penetration through the medial surface has been achieved. The sectioning is then completed by sharp chisel and mallet. Three or four firm, short, sharp blows with the mallet usually suffice.

11. If there is special concern about making a straightforward vertical cut between the inferior alveolar foramen and the mandibular notch above, closely spaced drill penetrations can be made with more safety, and this portion of the osteotomy can be completed with a chisel and mallet after the remainder of the osteotomy is completed. The character of bone in this area is the same as in the coronoid process, thin and without medullary space.

12. When *decortication* is indicated, and it most often is, a simplified, safer and faster method has been substituted for that previously described. A second vertical cut is made into the lateral cortical plate approximately parallel to and anterior to the first vertical cut (step 6), with care not to penetrate this cortex especially over the suspected course of the inferior alveolar canal; the two vertical cuts are then connected with several horizontal cuts spaced at about 6 to 8 mm intervals. These horizontal steps are made with a No 703 carbide fissure bur, which creates a notching effect that greatly facilitates subsequent decortication. These steps or notches need not be extended above the prominence caused by the inferior alveolar foramen. Any impingement or interference with bony aposition above this level should be dealt with as described.

13. By use of a sharp, long-beveled, broad, flat chisel (Stout's No 3 chisel is ideal) with the bevel down, the notched steps of cortex are fractured off without fear of injury to the inferior alveolar nerve and vessels. These cortical segments chip off cleanly, exposing the medullary spaces, and even the neurovascular bundle is usually visualized and its course identified. Having the bevel down allows for better protection for the nerve as the cortical segments are chipped off. It is helpful if the location of the neurovascular bundle is known when the vertical section is completed or when a hole is drilled to provide for transosseous wiring.

14. At this point, while the first side is still intact, one may wish to turn the patient to the other side and repeat steps 1 through 13. The operation on the second side is then completed as follows:

15. A sharp Molt No 4 curet is used to initiate elevation of the periosteum and anterior attachment of the medial pterygoid muscle, starting at the inferior border.

16. Once the elevation is started, a broad, blunt periosteal elevator is used to push off soft tissue to an approximate level of the lower margin of the mandibular foramen. *Troublesome bleeding may be caused if sharp elevation is used or if these medial attachments are raised too far.* A No 9 Molt periosteatome is recommended.

17. With a broad, protecting elevator in position on the medial aspect of the vertical cut, the incision through the bone is completed from the area of the inferior alveolar nerve to the lower border through the medial cortex of the ramus. Use of water and suction during all bur cuts in bone permits clear vision of structures encountered and protects the bone from injury.

18. The vertical section above the nerve is completed in the same manner or with a No 3 chisel and mallet, fracturing through the drill holes to the mandibular notch. Occasionally the No 702 bur can be used to facilitate the completion of the osteotomy at this level.

19. If the vertical sectioning is incomplete in a critical area, such as immediately around the neurovascular bundle at the foramen, a Lane periostotome may be inserted into the vertical cut and, with gentle manipulation, the thin remnants of uncut bone will usually fracture. In older patients or when the ramus is very thin, one must be careful to avoid fracture of the proximal fragment at the level of the foramen.

20. The proximal segment is rotated slightly to permit visualization of the medial surface. Periosteum and the medial pterygoid muscle attachments are elevated posteriorly but only enough to permit direct bone-to-bone onlay without soft tissue impingement.

21. Irregularities along the vertical cut, especially on the medial side of the proximal fragment, are planed away with a chisel or No 703 bur until acceptable adaption of the medial surface of the proximal (posterior) fragment can be anticipated when it is lapped onto the distal (anterior) decorticated surface.

22. At this point the patient's head is turned back to the first side and steps 15 through 22 are repeated unless these were completed initially.

23. Both wounds are now covered, and the "curtain" drape is turned down over the surgical fields, exposing the mouth. *On oral examination and when the jaw relation is inspected, the mandible should be hanging posteriorly in a completely free and unrestricted relationship and it should be possible to relate teeth into a predetermined occlusion without forceful effort. If this is not the case, coronoidotomy is indicated.* If impingement is present in the mandibular notch (subsigmoid) area or the sphenomandibular ligament is restricting movement, corrective measures should be taken.

24. The jaw is manipulated until desired occlusion is secured and intermaxillary elastic ligatures are generously placed. Firm fixation is necessary to prevent displacement as transosseous wiring of the osteotomy is accomplished.

25. The curtain drape is replaced to its previous position, instruments used in the mouth are discarded, gloves are changed, and the surgical field is reentered.

26. The posterior fragment is lapped onto the decorticated area anterior to the vertical osteotomy in a relationship visualized on the templates preoperatively. Both parts are held in the desired relation, and small holes are placed strategically for wiring. *The posterior fragment (proximal or condyloid part) should lap onto the decorticated part freely and without binding or bowing. If it does not, recheck step 22. It may be necessary to excise portions of medial cortex at points of impingement; the posterior fragment may be rotated outward somewhat to accomplish this. Occasionally the thin portion of ramus below the mandibular notch, above the mandibular foramen, requires sectioning. It need not be removed, simply depressed medially.*

27. The parts are not wired as securely as previously, since two undesirable sequelae can occur. The condyle may be distracted or rotated, which later may result in poorer occlusion than should have been expected, or there may be chronic temporomandibular joint pain. Usually a drill hole is made just anterior to the decorticated area, and a single, 0.016-inch stainless steel wire is threaded through and carried circumferentially around the stump of the proximal fragment. Usually the wire is not twisted tightly but only enough to assure reasonably good approximation of the parts. An exception is when the operation is used to correct apertognathia. In *all* cases one must always check to be sure that the condyle head is well seated in the glenoid fossa before the wire is tightened and the wounds are closed. The complication of operative condyle dislocation occurred in one of our cases, and reoperation was necessary 3 weeks later.

28. The tendinous attachments of the masseter and medial pterygoid muscles are picked up and closed together. The masseter muscle, which may have been entirely elevated, and the pterygoid muscle, partially or often completely elevated, are readily reapposed in their normal anatomical position. Their relationship to the bone that was moved may be changed, but reattachment in harmonious functional position occurs.

29. Closure of soft tissue is completed according to the prescribed technique. Careful attention is given to reapposition of tissues in proper anatomical relation to ensure a good cosmetic and functional result. It is especially important to close the platysma muscle accurately prior to the subcutaneous layer.

30. Pressure dressings are avoided. Gauze toppers are placed on the wound and held firmly with Kerlix gauze applied according to the Barton method.

Discussion. The necessity for sectioning the coronoid process has been a point of controversy. Our attitude toward the inelasticity of the temporal muscle explains why we consider this essential for the perfect results obtained in correction of moderate to severe prognathism. If one remembers that the central tendinous attachment of the temporal muscle extends for a considerable distance downward along the anterior border of the ramus and also broadly over the medial surface of the coronoid process, the effect of this sectioning should be clear; it is that of a hinge. As the body and anterior portion of the ramus are repositioned in the posterior direction, the coronoid process swings forward, with its tip remaining to a large degree in its original position. Its base anteriorly, still attached below and medially by the tendon of the temporal, is the joint of the hinge. The strong fibers of this tendon's attachment act much the same as the old-fashioned leather barn door hinge. Finally, bony union of the coronoid occurs.

Another point deserving clarification is application of the technique of vertical osteotomy in slight to moderate degrees of prognathism. Results have been equally good in all patients who have been operated on, but the technical details of the operation are more difficult in patients requiring less than 10 to 12 mm of correction than in more severe cases. There are two reasons for this: (1) decortication of a more narrow area anterior to the vertical line is more tedious than the broader area needed in extreme cases and the nerve is usually deeper, probably because the ramus may be thicker (mediolaterally) than in the longer, more obtuse rami and (2) the overlapping and mortising procedure. The proximal (posterior portion) of the ramus does not overlap as readily, and this fragment tends to "bow out". This usually can be overcome by partial decortication of its medial surface and other "fitting" bone adjustments as mortising is accomplished, following step 21 of the technique. For these reasons our operating time in minimal prognathisms is sometimes longer than in more extreme cases; however, as technique and operative skills have improved, our operating time never exceeds 3.5 hours and frequently is less than 2.5 hours, including coronoidotomy, decortication, and transosseous wiring. For these reasons we favor *vertical osteotomy* in more *extreme prognathic* surgery and *subcondylar osteotomy* in *less severe cases.*

Bell and Kennedy emphasize the importance of preserving as much soft tissue attachment to the proximal fragment as possible since the bone is entirely dependent on this source for nourishment and revascularization. In their research on adult rhesus monkeys, they found that when the proximal segment was not pedicled to soft tissue, there was a tendency to intraosseous necrosis, vascular ischemia, and delayed healing. Similar studies of *pedicled* vertical ramus osteotomies showed early osseous union and minimal osteonecrosis or vascular ischemia. One of their conclusions was that "osteonecrosis and sequestration of the relatively ischemic distal tip of the proximal segment might be obviated by sectioning the ramus more obliquely and thereby shortening the proximal segment or by excising the distal end of the proximal condylar segment." Their research is convincing, and the theory is sound. Their conclusions, however, are not entirely corroborated in practical application. In practice, neither making a "more oblique section" nor "excising the distal end" is practical in all cases. To the contrary, it is essential in certain situations for this proximal segment to be made extremely long. Other examples of the survival of bone when there are long extensions completely denuded (not pedicled) are illustrated. In practice, we have literally scores of cases in which extremely long extensions of bone were denuded as described previously, and in not one case have we observed resorption beyond that expected in normal remodeling. Perhaps the reason for this record is that we *decorticate* and *approximate the fragments* in a high percentage of cases.

In application of the "vertical osteotomy" technique for edentulous patients, careful preparation of the template from the cephalogram and measurements of its relationship are adapted arbitratily in the osteotomy. Positive, firm, intraosseous wiring of the sectioned parts usually provides adequate fixation and intraoral "Gunning" splints are not essential. Shira uses preoperatively fabricated and arbitrarily related splints, the lower of which he has secured by circumferential wiring to the mandible. Either procedure is satisfactory, and healing is such that dentures can be initiated 3 to 4 weeks after surgery.

Advantages

1. Although almost universally suitable for correction of all cases of prognathism that we have observed over a 25-year period, the procedure is especially applicable in cases of severe prognathism. It produces ideal results in patients requiring 10 mm or more of correction.

2. Clinically union occurs in 3 to 4 weeks, and relapse or nonunion has not occurred.

3. Simple fixation appliances suffice, eliminating a need for orthodoncti banding, elaborate splinting, or arch bars. (We use Stout's or multiple-loop intradental wiring in the majority of cases.)

4. As a result of advantages 2 and 3, teeth are not extruded or damaged by protracted stress.

5. Standard, comercially available instruments are used entirely.

6. Injury to the inferior alveolar and facial nerves can be completely avoided.

7. The body of the mandible is not shortened anteroposteriorly, and no teeth need be sacrificed as in ostectomy.

8. In addition to preservation of the alveolar ridge, the vertical dimension is positively assured in partially or completely edentulous patients, and dentures can be provided at an early date (initiated within 3 to 4 weeks).

9. Normal temporomandibular joint relation is also assured, and no joint malfunctional sequelae should occur in patients treated by this method.

10. In addition to excellent functional results, there is a cosmetic benefit in every instance. The characteristic obtuse angle deformity is corrected at the same time a good profile is achieved. Also, since early bony union is positively assured, no "open bite deformity" occurs.

Disadvantages

1. Operating time, which is ordinarily 2.5 to 3.5 hours, is not considered excessive or a disadvantage.

2. External scarring is minimal but is objected to by some patients; however, the incision line is indiscernible after 6 months in most patients. Those who, from history, tend

to form keloids may be treated prophylactically at the time of surgery by local injection of steroids.

Extraoral subcondylar osteotomy (oblique)

Subcondylar osteotomy for correction of mandibular prognathism was reported by Robinson and Hinds from independent endeavors. Both writers described open procedures with the line of osteotomy almost identically placed in the ramus. Robinson used a nasal saw to perform the osteotomy; Hinds made drill holes, used a No 8 round bur to cut a connecting groove along the line of holes, and then completed the osteotomy with an osteotome. Both operated through short incisions (2.5 to 4 cm), and neither saw a need for transosseous wiring. Robinson referred to his operation as *vertical subcondylotomy,* and Hinds referred to his as *subcondylar osteotomy.* Thoma referred to the same procedure as *oblique osteotomy.* He believed it to be the ideal method by which most Class III occlusal problems could be solved. All these osteotomies were in essentially the same location anatomically, and all were reminiscent of the "vertical osteotomy" of Caldwell and Letterman, the difference being that the line of bone incision was somewhat posterior to the mandibular foramen, no decortication or mortising was done, less hazard existing to the mandibular nerve, and the entire procedure was greatly simplified. Subcondylar osteotomy (oblique) is an acceptable operation for correction of mandibular prognathism, especially when protrusion is not extreme. It is a more desirable procedure than vertical osteotomy in minimal cases (less than 10 or 12 mm correction). It is definitely not the operation of choice in extreme cases, and therefore preoperative appraisal must *never* be neglected. Subcondylar osteotomy must not be utilized simply because it is technically easy. Its use must be limited to cases in which it is indicated. The need for simplified, standard subcondylar technique was recognized by Robinson, Hinds, Thoma, Kruger, and many others.

Technique for extraoral subcondylar osteotomy (oblique). Extraoral subcondylar osteotomy (oblique) follows the same general technique described for vertical osteotomy except for a few modifications.

1. The incision may vary in length from 2.5 to 4 cm.

2. The line of osteotomy is scribed from the lowest point in the mandibular notch obliquely (it may be a vertical line, depending on the obtuse angle of the mandible) downward to a point on the posterior border of the ramus, 1 to 2 cm above the angle of the mandible.

3. The osteotomy may be accomplished using a nasal saw or a No 703 carbide taper fissure bur. In either case, care must be exercised to avoid injury to soft tissues on the medial surface of the ramus. However, injury to the inferior alveolar nerve or vessels is not expected, since the line of osteotomy is posterior to the mandibular foramen.

4. Musculature and periosteal covering must be elevated sufficiently to permit lateral placement of the proximal (posterior) fragment and unrestricted movement of the distal (body) fragment posteriorly to a satisfactory degree.

5. Decortication of the lateral surface just anterior to the line of osteotomy is usually not contemplated, but, if it is desirable to obtain better bone apposition of the parts, it may be accomplished as previously described. Need for this step in the procedure should be

predetermined in the planning phase. Decortication, if needed, is more easily done before the sectioning has been completed.

6. Transosseous wiring may or may not be used, but wire ligatures should not be applied as a means of overcoming a tendency of the proximal fragment to "bow out" or displace posteriorly. If either situation exists, the meticulous surgeon will correct it to a necessary degree by decortication as indicated.

7. The rule governing coronoidotomy applies in subcondylar osteotomy also. If posterior movement of the jaw is limited, regardless of the measurement of correction, the coronoid process should be cut free from the distal (body) fragment. If it is contemplated, this step is also easier to accomplish before the sectioning is completed.

8. The teeth are placed in occlusion as already described (vertical osteotomy). However, immobilization should be accomplished by use of well-adapted arch bars or splints for 6 to 8 weeks to ensure against unnecessary injury to the teeth (extrusion), which may occur if ordinary intradental wiring is used for this period of time.

Advantages and disadvantages are similar to those enumerated for vertical osteotomy, with the following exceptions:

1. Longer immobilization period required (6 to 8 weeks as compared with about 4 to 5 weeks for clinical hearing in vertical osteotomy).

2. Probably more suitable for minimal to moderate deformities.

3. Shorter operating time (1.5 to 3 hours as opposed to 2.5 to 3.5 hours for vertical osteotomy).

Intraoral subcondylar osteotomy (oblique)

In 1968, Winstanley described an intraoral technique for subcondylar osteotomy using surgical burs in a straight handpiece and approaching the ramus from the lateral aspect. The major disadvantage of the procedure was the need for excessive elevation and retraction of soft tissues for access to the lateral surface of the ramus. Hebert, Kent, and Hinds, in 1970, reported using the Stryker oscillating saw and a 6-mm right-angle blade, which allowed for better visibility by way of the intraoral approach and also accomplished the osteotomy with much less soft tissue elevation. Since these first efforts, Massey and others have reported refinements in the procedure and good results in 14 patients operated on. They estabolished certain criteria for "mandibular divergence angles" that made possible the selection of patients on which the procedure would be acceptable. Others, reporting their experience with this intraoral operation, have endorsed it but describe varied morbidity.

After intraoral vertical (oblique) osteotomy in 125 cases, Walker has standardized his technique sufficiently that morbidity is minimal, and he also endorses the procedure. In our discussions, he emphasizes the importance of strict adherence to prescribed technique, use of prescribed instruments only, and good visualization. In his series of cases there has been less than 1% paresthesia, and *all* prognathic cases that he has admitted have been treated by this procedure, with the greatest correction being about 16 mm. All cases were immobilized for 8 weeks. We must endorse the operation based on reports available, but with reservation. As with any new operation, it is wise to observed the procedure before undertaking it. We prefer

to correct prognathic problems by way of extraoral operations; however, patients with a history of keloid formation and those who will not accept a skin incision may be offered this operation or the sagittal splitting procedure, but they must be fully informed of possible undesirable sequelae.

Technique for intraoral subcondylar osteotomy (oblique). Intraoral subcondylar osteotomy (oblique) is undertaken in essentially the same manner as described later on for intraoral sagittal osteotomy. Fixation appliances (orthodontic or arch bars) are placed prior to the operation. The oral pharynx is packed in the routine manner. The mucoperiosteal incision is made firmly onto the external oblique line from about the level of the inferior alveolar foramen to the area of the first molar. The mucoperiosteal tissues are elevated superiorly and held firmly in the retracted position with Obwegeser's V coronoid retractor. The periosteal and overlying soft tissues are elevated broadly from the lateral surface of the ramus from the level of the mandibular (sigmoid) notch to the lower border of the mandible. As soon as adequate access is available, the LeVasseur-Merrill intraoral retractor fitted with a fiberoptic light is introduced to provide visualization necessary to accomplish the osteotomy. The mandibular (sigmoid) notch, posterior border of the ramus, angle of the mandible, and convexity of bone over the mandibular foramen are positively located. With these landmarks well in mind, the osteotomy is accomplished using the Stryker gas-powered saw fitted with an 11-mm blade offset at a 20-degree angle. The cut is made from the lowest point in the mandibular (sigmoid) notch obliquely down toward the angle or slightly above it and posterior to the mandibular foramen. Coronoidotomy and circumramus wiring are optional depending on the surgeon's judgment of the individual case, keeping in mind the tendency of the condyle to "sag" from the glenoid fossa. Wiring is technically difficult and adds considerably to the operating time but may be essential for a good result. Routine supportive care used in all intraoral operations is necessary, including steroids to control edema, antibiotic prophylaxis to prevent infection, and vacuum drains to prevent hematoma formation.

In addition to the usual immediate postoperative swelling and lip abrasions, there may be long-term sequelae that may be of some concern. Hypoesthesia or anesthesia over the distribution of the mandibular nerve has been common; necrosis of the tip of the proximal segment has been reported on occasion; condyle displacement (sag) and, secondarily, occlusion relapse and anterior open bite may occur.

Horizontal osteotomy in the rami

Blair first proposed horizontal osteotomy in his original article on developmental deformities in 1907. In the past many surgeons were proponents of the method, but there is never an indication for the operation today. As originally conceived this procedure appeared to be simple and consisted of passing a long, curved Blair needle or a Gigli saw guide through a short skin incision at the posterior border of the ramus, introducing the Gigli saw to the medial surface of the ramus above the foramen, and making the section. The hazards were numerous, including possible (1) injury to the branches of the facial nerve, (2) hemorrhage resulting from severance of the maxillary artery, (3) severance of the inferior alveolar nerve, which may not regenerate, resulting in permanent anesthesia to the teeth and lower lip of the injured side, and (4) injury to the parotid gland or its capsule, with formation of salivary fistula.

Because of these potential hazards, "blind" horizontal osteotomy has been discarded as an acceptable operation, and the only reason for reference to it is for its historical value. Many of today's accepted orthognathic procedures have evolved from practices and techniques

of an earlier era. Perhaps the widely used intraoral sagittal osteotomy is an evolution from Blair's horizontal osteotomy of 70 years ago. One of the first modifications of the bling Gigli saw procedure was offered by Hensel in his appraisal of deformities of the mandible in 1937. Based on photognathostatic studies, he specifically located the ramus osteotomy on an oblique line from high on the coronoid process downward and posteriorly to the posterior border of the ramus, passing through a central safe area midway between the sigmoid notch and the mandibular foramen. He advocated a direct surgical apporach to ensure a correct line of osteotomy.

Moose in 1945 proposed an intraoral direct visualization osteotomy, which he performed with an orthopedic, power-driven, short-stroke, cross-cut saw (designed by Dr E A Cayo of San Antonio, Texas). By utilizing the intraoral route the hazards of blind osteotomy were lessened. Moose also endorsed a hand saw suggested by Sloan in 1951. Sloan suggested wiring the sectioned parts in apposition by looping a strand of stainless steel wire over the sigmoid notch and tying the proximal fragment down to the anterior border of the distal fragment of the ramus through a drill hole previously placed. Skaloud also recommended this method of fixation, although he performed the osteotomy using a Gigli saw. The result, of course, was vertical collapse and foreshortening of the ramus.

In 1941 Kazanjian advocated horizontal osteotomy above the mandibular foramen by an extraoral Risdon submandibular approach and accomplished the section using a surgical bur. Later, in 1951, he recommended an incision through the bone on an angle using a sharp osteotomy. He believed that "beveling in this fashion allowed for a greater area of contact of the cut ends, promoting early consolidation." This may have been the initial conception of the Obwegeser-Dal Pont sagittal splitting procedure (see section on intraoral sagittal osteotomy following).

The disadvantages of horizontal osteotomies in the ramus were numerous and included a tendency to (1) open bite anteriorly produced by the power of the major masticator muscles and the counter action of the depressor muscles, (2) nonunion induced by minimal bone opposition and the displacing action of the musculature, and (3) the need for excessively long periods of immobilization resulting in secondary damage to the teeth.

Intraoral sagittal osteotomy

Intraoral operations for correction of a wide variety of facial and jaw deformities are often indicated and desirable. Obwegeser described a method of splitting the vertical ramus of the mandible sagittally. He surgically modified conditions he had noted in some traumatic fractures of the vertical ramus. His method added many improvements to earlier operations proposed by Moose, Schuchardt, and Kazanjian. Dal Pont later added modifications that Obwegeser endorsed as definite improvements of the original procedure. Dal Pont's modifications ensured a broader bony contact surface and an esthetic improvement of the gonial angle. Bell and Schendel have recommended an additional modification of the sagittal ramus split operation (Obwegeser-Dal Pont) that eliminates the wide detachment of periosteum and masseter and medial pterygoid muscle attachments to reduce the amount of vascular ischemia induced in the proximal fragment of the mandible when operated on by the original method. Their animal studies, beautifully illustrated, leave no doubt that the reduced elevation of tissues contiguous to the mandible results in a richer blood supply to the osteotomized bone postoperatively, thus reducing materially the incidence of complications and degree of morbidity.

Technique for intraoral sagittal osteotomy. The procedure suggested by Obwegeser and modified by Dal Pont is as follows.

1. An intraoral incision over the anterior border of the vertical ramus of the manidble and the external oblique line is made through mucosa and periosteum from 1 cm above the depths of the curve on the anterior border to the area lateral to the second bicuspid tooth. Care is taken to prevent excessive lateral retraction of buccal tissues, which would cause difficulties in final closure. Specially designed Obwegeser retractors of the Army-Navy type but with longer retracting arms provide the best retraction at this point.

2. The periosteum lateral to the mandible is elevated with a sharp broad-bladed elevator to the inferior border and posteriorly to the posterior border of the vertical ramus. A long-bladed Obwegeser retractor is inserted well into the space between periosteum and bone to retract the lateral flap.

3. Medial tissues superior to the mandibular foramen on the medial side of the vertical ramus are also elevated with a borad-bladed elevator. Care must be exercised to avoid damaging the inferior alveolar nerve, artery, and vein. For this reason, dissection is carried superiorly initially to the sigmoid notch. When this landmark has been located, dissection is carried posteriorly and slightly inferiorly to the posterior border of the vertical ramus.

4. When sufficient periosteum has been elevated medially, a channel retractor of the type recommended by Obwegeser is inserted with care to protect the inferior alveolar neurovascular bunlde. Excessive medial retraction at this point can cause damage to the nerve and vessels as they are stretched over the sharp edges of the mandibular foramen. The technique for insertion of the channel retractor follows closely that for the elevation of the periosteum; it is inserted toward the sigmoid notch, then slightly inferiorly toward the posterior border of the vertical ramus.

5. The periosteum lateral to the mandible is now elevated from an area between the sigmoid notch and the second bicuspid tooth. The remaining tissues adherent to the posterior and inferior borders of the mandible are elevated by the properly curved, side-cutting periosteal elevator suggested by Obwegeser. Complete elevation of these tissues is essential to the successful accomplishment of the operation.

6. The medial bony incision is accomplished by first gaining better vision of the area by making a shallow groove at the anterior end of the proposed bur cut with a Hall No 1377-07 bur. A horizontal cut with a Hall No 1373-15 bur is made at a level inferior enough to engage the thicker portion of the ramus in this area and superior enough to avoid the inferior alveolar neurovascular bundle. This cut is made from posterior border to anterior border to a depth of one half the mediolateral thickness of the ramus in this area. The use of an extra light source such as that provided by the Viconex system adds immeasurably to the operator's assurance of adequate visualization of the operative field.

7. The placement of the bony incision on the lateral cortical plate is now made in the area recommended by Dal Pont in his modification of Obwegeser's original operation. The anatomical configuration of the mandible lateral to the molar teeth is the key to the placement of the lateral cut. Indeed, the breadth of the area between the molar teeth and the external oblique line is the indicator thether sagittal osteotomy is surgically feasible. The lateral bony incision is made perpendicular to the inferior border of the mandible, down to bleeding bone,

from the external oblique line to the true inferior border. The more anterior the cut, the easier the splitting procedure becomes.

8. The medial and lateral cuts are not connected along the anterior border of the ramus with a No 700 bur. The narrow cut prepares the area for a true splitting action by the osteotomes.

9. The mandible is now split by the use of broad, thick osteotomes to which a sharp staccato blow with the surgical mallet is applied. The osteotome must be directed parallel to the lateral cortex of the ramus. Further splitting is accomplished by twisting and prying with one or two Obwegeser osteotomes at the same time. The orthopedic chisels in common use, although large enough, do not have handles that facilitate the necessary twisting action.

10. The contents of the mandibular camal are usually visualized at this time. Care must be taken to ensure that they are not adhering to the proximal fragment. The preceding steps are repeated on the other side.

11. The throat pack is now removed and the teeth fixed in the prearranged occlusion with intermaxillary fixation. The proximal fragments is now positioned and its proper length established in the case of the prognathism operation or merely properly positioned in the case of the retrognathism operation. A so-called upper border wire is placed posterior to the second molar tooth area bilaterall, with care taken that the mandibular condyle is in the glenoid fossa.

12. A suction catheter is placed lateral to the mandible along the entire length of exposed bone and brought out of the wound through a stab incision in the buccal sulcus anterior to the distal extent of the operative incision. The wound is then closed with a running horizontal mattress suture. *No pressure dressings are used.* Antibiotics and sterois such as dexamethasone (Decadron) are prescribed routinely.

Ostectomy in the body of the mandible

There is rarely an indication for *ostectomy* in the body of the mandible for correction of prognathism. When performed, it consists of the excision of a measured section of the body of the mandible to establish normal relation of the anterior teeth and correct protrusion of the lower jaw. It may be performed by an intraoral approach, an extraoral approach, or a combination of both in one or two stages.

Blair described this operation first in 1907. He used a hand saw for removal of bone in the bicuspid or molar region. In 1912 harsha reported a case in which he had corrected prognathism by excision of a rhomboid section of bone from the third molar area. The section removed was wider above than at the lower border of the mandible in an effort to increase the angle from the obtuse deformity, which is characteristically observed in prognathism. He used "bone-cutting forceps and rongeurs" to accomplish the excision of bone and then placed "wire sutures to maintain apposition of bone during healing". New and Erich in 1941 favored ostectomy in the bicuspid or first molar regions and preferred to accomplish the surgery by an open method "in which the mandible is exposed both externally and from within the mouth". Excision of bone was accomplished by a combination of a motor-driven circular saw, chisel, Gigli saw, and rongeurs in an effort to preserve the continuity of the mandibular nerve. In 1948 Dingman made a comprehensive review of the literature on prognathism and also made a detailed appraisal of various methods utilized for its surgical correction. He had previously described in 1944 a two-stage method of ostectomy in which he overcame the

disadvantage of compounding the extraoral surgical wound intraorally and at the same time avoided injury to the mandibular nerve. These articles were classics and served to popularize ostectomy in treatment of prognathism. Ostectomy, or the Dingman two-stage operation, as it is frequently referred to, was probably the most widely used of all the methods in the late 1940s and early 1950s. Thoma recommended intraoral ostectomy utilizing bone drills and osteotomes. Ramus osteotomies, except horizontal, are indicated in almost 100% of prognathic mandible corrections in prefernece to *ostectomy* in the body by any method. *Osteotomy* in the body is indicated in certain cases, especially *asymmetrical prognathism.*

Technique for ostectomy in the body of the mandible. When correction of prognathism by ostectomy is indicated, it may be accomplished at one operation or in two stages. In our opinion the two-stage approach is rarely indicated. Complete ostectomy in a single operation is much more desirable. In operations such as this that are open and directly communicate to the oral cavity, antibiotic prophylaxis starting the day prior to surgery is indicated.

1. The patient is specially prepared for the initial part of the operation by thorough washing of the face with surgical soap and scrupulous cleansing of the oral cavity. Draping is standard for operations in the mouth.

2. Incisions are made into the interdental papillae adjacent to the site of the ostectomy and also through the mucoperiosteum at the crest of the edentulous ridge if a tooth has been removed previously.

3. An incision should be carred obliquely anteriorly and downward into the buccal vestibule, one or two teeth anteriorly to the site of ostectomy.

4. Since no such oblique incision should be made on the lingual aspect of the madnible, it is usually necessary to incise papillae as far forward as the cuspid or lateral incisor to permit detachment of the lingual periosteum without tearing.

5. The mucoperiosteal flap on the buccal aspect intraorally is then elevated from the bone. Caution is exercised to protect the mental nerve. For flap retraction intraorally, a smaller periosteotomy (Molt No 9) is preferred, and therefore both the No 2 and No 4 Molt curets are used for periosteal detachment and elevation.

6. The lingual flap is raised in a similar manner down to the mylohyoid muscle. It need not be detached at this time.

7. For precise bone incision, a caliper or measured metal template is used to guide the bone cuts.

8. Vertical cuts across the alveolar ridge are accomplished with a No 703 fissure bur in an 18.000 rpm engine and handpiece to a safe level above the course of the mandibular nerve. They are extended as low as possible into both buccal and lingual cortices, and the alveolar portion of bone is removed by rongeur and chisel and mallet. The inferior alveolar nerve may or may not be seen at this time.

(If the operation is to be completed in one stage, the intraoral wounds are covered with moist gauze sponges but not closed. If a delayed "second stage" is planned, the following steps 9, 10, and 11 are carried out.)

9. The soft tissue flaps are closed as each side is completed, and the wounds are permitted to heal for 3 to 5 weeks before the second stage of ostectomy is undertaken.

10. During this interim period between the two surgical procedures, the fixation appliances (splints or orthodontic appliances) are prepared and inserted.

11. Local anesthesia may be utilized for all preparatory work, including the first surgical stage. The patient need not be hospitalized unless a specific, unusual reason makes this necessary.

12. The skin of the face and neck is again prepared by washing with soap and draped for the extraoral surgery, and the versatile curtain draping technique is used, since the mouth must be entered later in the operation.

13. The soft tissue dissection extraorally is carried out as previously described.

14. When the lower border of the mandible is reached, the periosteum is incised sharply, and then, using a Lane periosteotome in the left hand for retraction of soft tissue, the surgeon elevates the periosteum sharply with a Molt No 4 curet.

15. The mental foramen will come to view quickly on the lateral aspect of the mandible, and elevation of the periosteum is carried superiorly beyond it, with caution being exercised to protect the mental nerve. Blunt spreading of soft tissues around the nerve with a curved mosquito forceps will gain relaxation of the flap as it is elevated and prevent damage to the nerve. The cuts in the lateral cortex will be visualized for orientation of the final phase of ostectomy.

16. Periosteum on the medial aspect is elevated in the same manner and with no more difficulty until the attachments of the mylohyoid muscle come into view.

17. Both the lateral and medial surfaces of the bone should be exposed for a distance of 4 to 5 cm for adequate access for bone excision without injury to soft structures.

18. A No 703 carbide bur is used to complete the previously made bur cuts down to the lower border of the mandible. These cuts on the lateral aspect of the mandible are made through cortical bone only. The shape of the bone segment outlined by the bur cuts has been determined by previous careful measurement. For those who are more comfortable using a Stryker saw the vertical cuts can be done using a reciprocating blade.

19. When both vertical cuts through the cortex are completed, they are connected anteroposteriorly at the lower border of the mandible with the No 703 carbide bur. (All bone cutting with the bur should be irrigated with sterile saline solution to prevent thermal damage to bone.)

20. A broad, flat-bladed periosteotome is now placed into the anteroposterior connecting cut at the lower border of the mandible and turned, thus elevating off the lateral cortex.

21. The mandibular nerve is exposed and identified by removal of cancellous bone with curets.

22. The medullary bone is removed in this manner until the dense substance of the lingual cortex is reached. The cortical plates anterior and posterior to the cuts are undermined slightly by scooping out more medullary bone to create space into which the nerve and vessels may coil when the ends of the bone are approximated.

23. The inferior alveolar neurovascular bundle is protected with a blunt retractor (Molt No 9), and the soft tissues lingual to the mandible are guarded with a broad Lane periosteal elevator.

24. Assuming that transosseous wiring is planned, drill holes to accommodate it are made at this time using a No 14 bone drill in the handpiece.

25. With protection afforded as in step 12, the ostectomy is completed through the lingual cortex using the No 703 carbide bur at 18.000 rpm under saline irrigation. As this plate of bone is removed, the mylohyoid muscle attachments must be sharply dissected free to avoid tearing.

26. Lingual ostectomy on the first side may be left incomplete until the second side is finished to afford stability of the jaw as the surgery progresses.

27. When the lingual ostectomies are completed, the transosseous wires are placed in both sides, but they should not be tightened completely at this time, merely enough to hold the parts in approximate relation with some movement still possible.

28. The mouth is now entered. Intraoral soft tissue flaps are replaced and sutured. Previously placed fixation appliances are secured and intermaxillary immobilization is accomplished with the teeth in the desired new occlusal relationship.

29. Gloves are changed, and the extraoral wound is again entered.

30. If the ostectomy was properly planned and executed, the bone ends should now be in close apposition. The wire sutures are twisted down tightly to add to the stability of the mandible during healing.

31. Thw wound is closed in anatomical layers as previously described, but a small rubber dam drain should be placed from deep in the wound to the outside. Since we routinely keep our dressings of for 4 days, the drain is not removed until the fourth day, when the sutures are also removed.

Technique for intraoral ostectomy. The intraoral ostectomy suggested by Thoma requires more extensive reflection of buccal and lingual mucoperiosteal flaps intraorally. In fact, the buccal exposure must be to the lower border of the mandible, a procedure difficult to achieve and still protect the mental nerve. The operation should be done with the patient under general anesthesia, because complete relaxation is essential. Its application is somewhat limited, and patients with large mouths and pliable, tractable tissues are most suitable for it.

The excision of bone is achieved in the same manner as described previously, using No 703 carbide burs in a handpiece driven by an 18.000 rpm engine, with removal of the lateral cortex, exposure and identification of the mandibular nerve, and then excision of the medial or lingual cortex. Thoma preferred long-shanked Henihan drills in a contra-angle handpiece, since they are long enough to penetrate both cortices of the bone. It is more

difficult to control the progress of the bone incision with a contra-angle handpiece, and, furthermore, one can never be positive as to the exact location of the nerve until it can be uncovered laterally. It has also been difficult to perform the cuts in the precise direction desired, even when the facial muscles are completely relaxed. Completing the ostectomy from an extraoral approach is therefore preferred, unless the patient is absolutely and unalterably opposed to an external scar.

Advantages of ostectomy. The advantages are few:

1. Dissection through the soft tissue to the lower border of the mandible at the midportion of the body can be accomplished quickly, and adequate access to the site of ostectomy is acquired without difficulty.

2. Excision of bone can be done without injury to the mandibular nerve, and if the nerve is damaged, it tends to recover.

3. Immobilization of the sectioned bone is possible when stable teeth are available in both fragments and the parts are secured by intraoral splinting or orthodontic appliances augmented by transosseous wire ligatures.

4. An acceptable cosmetic result can be achieved in slight to moderate cases of prognathism.

Disadvantages of ostectomy. Following are the distadvantages to be considered:

1. Although a good profile can be produced in every case, a good cosmetic result is not attained in moderate to extreme cases of protrusion for the simple reason that the obtuse angle of the mandible is not corrected by the surgery. The excision of bone in the body merely shortens the length of the bone, and the obtuse gonial angle deformity is often accentuated.

2. If it becomes necessary to remove more than one tooth, the sacrifice of functional surfaces is too great to contemplate this method, thus contraindicating the procedure in moderate to extreme prognathism. When two teeth on each side are sacrificed, the difference in the transverse distance between the two second molars and the two first bicuspids is excessive, and the degree of medial rotation of the proximal fragments is unduly great. Also one must consider the decrease in area available to the prosthodontist if the patient subsequently becomes edentulous.

3. Nonunion, although not a common occurrence, is a complication to be considered. The potential is in direct proportion to the degree of bone end approximation and postoperative immobilization, not to speak of the possibility of contamination from the oral cavity and possible postoperative infection. If, through miscalculation in bone excision, the bone ends are not in direct apposition, nonunion may occur. If as much as 2 to 3 mm of space exists, nonunion is sure to result. Absolute immobilization of the parts is also essential if union is to be assured.

4. Firm clinical union cannot be expected in much less than 8 weeks in the most favorable cases and may not be attained for up to 3 months or more.

5. It is cited as an advantage by advocates of osteotomy that the muscles of mastication are not interfered with; however, no mention is made of the action of the depressor muscles and their continual action tending to produce open bite. If this does not occur, there is the tendency of the anterior teeth to be extruded because of this muscle action. Preoperative tongue thrust habits may add to these complications.

6. External scarring is an objection unless ostectomy is done intraorally. This should not be objectionable if the incision is well below the lower border of the mandible and closure is carefully accomplished. However, occasionally resulting from an excessive bulk of soft tissue, an irregular scar with "folding" is observed.

Asymmetrical mandibular prognathism

Asymmetrical mandibular prognathism is nothing more than a greater protrusion of the mandible on one side than the other, which results in *deviation* to the side of lesser growth. Hinds and Kent refer to this deformity as a "horizontal asymmetry", which is a good description since there is no condylar or mandibular hypertrophy. The deformity is manifest (1) in the occlusion in which there may be unilateral or bilateral cross bite, a greater Class III discrepancy on one side, and shift at the midline to the side of lesser growth and (2) in the appearance when the prognathic look is not as dominant as the asymmetry of the lower one third of the face in a front view.

Study of models will usually indicate that rotation to the side of greatest growth will produce a normal occlusion; thus, operations used for correction of ordinary prognathism are suitable for correction of most of these problems.

When there is Class I first molar relation on one side and Class III on the other, *unilateral vertical osteotomy* and rotation to that side of greatest growth will usually suffice. Because of the rotation, the proximal fragment will overlap without later bowing and decortication is not needed. Osseous wiring is recommended. Also as a result of the rotation, a slight torque occurs in the temporomandibular joint on the unoperated Class I side. The joint adapts to the change, and patients as a rule have no subjective complaints. When there is extreme asymmetry (8 to 12 mm of deviation), it is better to perform a simple vertical or oblique osteotomy on the second side, with osseous wiring optional, and thus eliminate the risk of undesirable joint sequelae. If there is Class III occlusion on both sides, but more on one than the other, it is obvious that bilateral osteotomies are indicated and that decortication will probably be appropriate on the side of lesser correction. This is associated with the lateral swing of the distal (body) fragment at the site of osteotomy in the ramus as rotation to normal occlusion is achieved. If this decortication and morticing is not done, the proximal fragment will "bow out" laterally to an undesirable degree.

When there is *normal Class I occlusion without cross bite* on one side but Class III malocclusion on the other side, plus deviation, vertical or oblique osteotomy in the ramus is indicated on the Class III side while osteotomy or ostectomy should be done in the body of the mandible on the other side at the point where discrepancy in occlusion occurs. This body osteotomy follows the same general technique described previously for ostectomy except that a tooth need not be extracted and the operation is not staged. The vertical cut on the lateral (buccal) surface is made with a Stryker reciprocating saw or a No 701 taper fissure bur but is made through the cortical bone only. The vertical osteotomy is begun intraorally, using the No 701 bur to positively locate the cut in the alveolar part exactly between the teeth - again avoiding penetration into medullary space. Cortical bone on the medial surface is sectioned

with a No 703 bur, and it may be necessary to excise as much as 6 to 7 mm of this bone to permit the rotation that is necessary. Orthodontic appliances or a cast splint are recommended for fixation of this body osteotomy, since union of bone in this area takes about 8 weeks and firm immobilization is essential.

Supportive and postoperative care

The details of supportive and postoperative care must be governed by the extent of surgery and the requirement of the individual patient.

With the mandible immobilizaed by intermaxillary elastic ligatures, it is routine practice to pass a nasogastric tube through the unused nostril to the stomach so that it can be partially emptied by suction on completion of surgery. This does much to eliminate nausea, and if vomiting does occur, it is of such minimal proportion that no hazard to the airway develops.

If the patient is not reacting from the anesthetic when ready for transfer from the operating room to the recovery room, he should be placed on the litter or his bed *on his side* to ensure dependent drainage of fluid from the mouth. While in the recovery room he should be moved from one side to the other occasionally until he has completely reacted. It is also wise to impress on the patient that when he awakens from anesthesia his jaw will be fixed closed so that he will not fight against the appliances or become panicky. From this time on emergency instruments, such as scissors, wire cutters, and a tracheostomy set, should be immediately available at the bedside to permit immediate access to the oral pharynx in case of airway obstruction.

Fluid requirements must be met. When the patient has been deprived of fluids for several hours prior to surgery, the daily requirements must be furnished by intravenous infusion during the day of surgery. The type of replacement must be calculated individually. If an excessive blood loss has occurred, part of the replacement may be in the form of whole blood. If the patient has lost fluids through the skin (perspiring), part of the replacement may be in the form of saline infusion. The bulk of fluid replacement, however, is usually in the form of 5% glucose in distilled water or Ringer's lactate solution.

Patients undergoing this type of surgery may require antibiotics to protect against infection, but this is a matter of judgment in each case. Intraoral operations demand antibiotic protection.

Pain can be controlled by administration of appropriate opiates or anaglesics.

Decreased postoperative edema has been noted when proper drainage and steroids have been employed.

Ordinarily if the patient has not voided within 6 to 8 hours after returning to the recovery ward, catheterization is indicated.

If normal bowel movements have not occurred by the third day, an enema should be ordered.

Early ambulation hastens recovery. The patient is permitted bathroom privileges on the first postoperative day, and activity is encouraged thereafter. Most patients are discharged on the third or fourth postoperative day.

The initial dressings are left in place until the fourth or fifth postoperative day at which time all sutures are removed, but the skin is immobilized with collodion gauze strips for another week or more.

Relationship of musculature to surgical correction of jaw deformities

In appraisal of various surgical methods of correction, authorities on the subject invariably consider the effect that musculature has on the healing of the jaw and the influence that this musculature may exert in causing relapse or a tendency to reversion of the part to its former malrelation. In the past, if the cosmetic objective was achieved, the result was considered to be satisfactory even when function was impaired or bony union had not occurred. This philosophy is no longer tenable. Complete repair and good function must always be expected as well as improved appearance.

The complexities of this matter of muscle balance, abnormal stresses, and imbalance resulting from surgery vary with the extent of repositioning and the operations performed in surgical correction. The compensatory powers of the musculature are often adequate ro reestablish normal function after corrective surgery, although the direction and functional length of muscles are changed. However, certain limitations to the adaptability of the musculature must be recognized and due cognizance taken when a method of surgical correction is selected.

Foremost of the muscles that potentially mitigate against good results is the temporal. It is bipennate muscle, which, according to Batson, "accounts for the *short length of the muscle fibers* and for the strong pull that this muscle exerts". Batson's description of the muscle and its attachments, action, and function explains certain difficulties encountered in surgical correction of jaw deformities, especially prognathism. He states that "from anatomic evidence the temporal muscle is capable of lifting the coronoid process some fifteen millimeters and retracting it severe or eight millimeters".

The strength of the temporal muscle was noticed especially after horizontal osteotomies above the mandibular forament when the coronoid process tended to rotate superiorly. The tendency is present after intraoral sagittal osteotomy, but good opposition of bone and transosseous wiring prevents a problem.

Clinically we have observed that the temporal muscle places a definite restriction on the posterior repositioning of the mandible in operations in which the coronoid process is carried back with the body of the mandible (osteotomy in the condylar neck, subcondylar or oblique osteotomy and vertical osteotomy in the ramus). This places a definite limit on the amount of correction that may be successfully achieved by blind osteotomy through the neck of the condyle. We are positive of this restriction imposed by the temporal muscle, because in vertical osteotomy by the open surgical method, we have been unable to obtain adequate posterior movement in certain instances after the verical section has been completed until the coronoid process with its muscle attachments has been sectioned free. About 1 cm seems to be the limit of repositioning freely obtainable without coronoid section.

The lateral pterygoid muscle is probably least affected of all the muscles of mastication in any of the operations for correction of prognathism. It probably also has the least effect or interference with the reestablished positions of the mandible. It may tend to distract the head of the condyle after osteotomy through the condylar neck, and nonunion may result.

The medial pterygoid and masseter muscles, because of their overpowering strength, possess a great potential to cause overriding of cut bone ends after horizontal (sliding) osteotomy above the mandibular forament, and direct transosseous wiring is unreliable to counteract the tendency. This plust the action of the hyoid depressor group of muscles creates a forceful muscle action, with the posterior teeth acting as a fulcrum, and accounts for the tendency to open bite in the anterior part of the mouth. According to Reiter open bite does not occur in condyle osteotomy as a result of these same factors because of the counteracting action of the temporal muscle. However, bilateral traumatic fracture-dislocations of the condyles that are untreated surgically have posed many plaguing problems of open bite. On this basis it seems that the entire musculature would also operate to produce open bite complications after osteotomy in the condylar neck.

The effect on the action and function of the medial pterygoid and the masseter muscles after vertical osteotomy in the ramus is negligible. This is because the masseter muscle is elevated intact from its mandibular attachments and the medial pterygoid is partially elevated. After the sectioning of the bone is completed and the parts repositioned, the muscle attachments are returned to essentially their original relationship, and their detached stumps are sutured together under the lower border of the newly established gonial angle. Thus healing and reattachment may occur in normal functional position as a result of shifting the location for the muscle insertions.

The depressor or suprahyoid musculature functions in harmony with the principal muscles of mastication and also the infrahyoid muscles. This group action common to muscles throughout the body may be disrupted after traumatic injury or surgical ostectomy. Interruption in unity of the body of the mandible bilaterally is followed by a tendency to distraction of the anterior segment (distal fragment) inferiorly. Thus, in addition to the part played by these muscles in contributing to the open bite tendency after osteotomy in the ramus, they also exert considerable influence toward separation of the bone ends after ostectomy in the body of the mandible and open bite anteriorly. Although not great, this effect is present and must be combated by proper fixation appliances.

The complex musculature of the tongue is another factor worthy of comment. This powerful group of muscles, by virtue of uninhibited or uncorrected "habit", is a potent factor in the tendency of the mandible to return to a preoperative protrusive or open bite relationship. Added to the actions of the depressor group, the tongue musculature has considerable displacing effect after osteotomy or ostectomy. This plus the action of the major muscles of mastication may constitute the total force needed to overcome fixation appliances after any corrective jaw surgery. Direct transosseous wiring cannot be relied on under these conditions either. The combined force of all these muscles places a tremendous stress on the teeth bearing the fixation appliances, and over long periods of immobilization, even though this musculature may relax from trismus and compensate to a degree to new relations and length, there is undoubtedly a great potential for irreversible damage to the teeth and supporting structures. If a tendency to relapse is observed after correction of any deformities, especially in cases of apertognathia, partial glossectomy may be indicated after mobilization of the mandible.

In addition to unfavorable thrusting habits the tremendous bulk of the tongue in patients with extreme protrusion has been a matter of considerable concenr. Conceivably it could result in mechanical obstruction of the oral pharynx, since the tongue, in its entirety, is also repositioned posteriorly when the mandible is retruded to desired occlusal relationship. Added to these mechanical factors is the potential of edema. Ample precautionary postoperative observation is necessary.

Fixation appliances and immobilization

Arch bars or custom-made cast labial splints are indicated for fixation of the mandible after any corrective surgery in which immobilization is expected to extend beyond 4 weeks. They should be well adapted to afford protection to the teeth against movement or extrusion over protracted periods of immobilization.

Since it is technically difficult to remove a section of bone with absolute accuracy of measurement (as in ostectomy in segmental operations), some type of adjustable appliance should be planned. Many surgeons obtain orthodontic banding for this reason even if orthodontic treatment is not contemplated, and this may be the most practical and dependable appliance.

The simple expediency of Ivy loop or multiple-loop wiring should not be utilized except when fixation is needed for only a short period of 3 to 5 weeks. This type of fixation is utilized in vertical osteotomy, since the desired occlusion can be established with greater accuracy.

Robinson is a strong advocate of the use of an intermaxillary splint (clear acrylic "wafer") interposed between the teeth at the time of surgery to ensure postoperative occlusion. Use of such a splint is hgihly desirable when many teeth are missing and a relation cannot otherwise be positively assured. Routine use of the inermaxillary splint is not desirable or recommended, especially if good jaw relation and reasonably good occlusion are anticipated.

It has been noted already that edentualous patients with prognathism can be treated by vertical osteotomy in the ramus without benefit of intraoral splinting or immobilization, provided that firm transosseous wiring is inserted. No doubt dentures or Gunning-type splints wired to place give added stabilization and ensure correct jaw relation during healing.

Discussion

As previously stated, no single operation is universally applicable to all deformities of prognathism. Before undertaking the surgical correction of these deformities, the problem must be evaluated thoroughly by all adjunctive diagnostic means available. Preoperative planning and selection of a proper technique for correction of any given case of prognathism cannot be overempahsized. When several acceptable techniques are available, the surgeon should select the method most suited to the problem. Size of individuals is variable, and it is possible that a small woman with 1 cm of protrusion of the mandible would be considered as having prognathism, whereas a large man needing 1 cm of correction might be considered as slightly prognathic. As an average, vertical osteotomy is recommended in cases requiring correction in excess of 1.5 cm.

Modification of any standard operation is often needed. For example we have varied the vertical technique that we reported in 1954 many times since then, and in 1963 the most

severe prognathism in our experience was treated by a modified vertical operation. The patient was a 33-year-old man whose prognathism measured 32 mm. No occlusion of teeth was present because of the gross size of the mandible and its complete encirclement of the maxilla. It was evident that correction of the problem could only be achieved in the ramus. Osteotomy at the base of the condylar neck, subcondylar (oblique) osteotomy, and vertical osteotomy were considered, but none of these procedures appeared to be acceptable. A modified vertical operation was planned and used with good results. Decortication, coronoidotomy, and transosseous wiring were necessary to achieve the correction. It was also necessary to obtain access through a fairly generous submandibular incision and to elevate all involved musculature to permit unrestricted posterior repositioning of the mandible. It must be concluded then that simplified techniques have a place in corrective jaw surgery, but that more difficult technical procedures must be mastered also.

Another lesson of importance is that no infallible rule exists regarding the correct age to operate on prognathic patients. The patient illustrated grew 2 inches in height from age 20 to 28, and he is certain that his mandible grew more after age 20 thanduring his teen-age years. He was a rare exception and should not influence criteria for surgical scheduling. However, all prognathic patients should be advised of this possibility, and most physically mature teenage patients should have their surgery deferred and be measured cephalometrically for at least 1 year before surgery is provided. We generally believe that prognathic deformity attains its maximum when full body growth and development is attained. In boys this is usually age 16 to 18 and in girls about 2 years earlier. Psychological problems and poor social adjustment often justify consideration for surgery earlier.

Mandibular Hypertrophy (Unilateral Macrognathia)

Mandibular hypertrophy is a rare overgrowth of the mandible, occurring on one side only. There is associated hyperplasia of the condyle head, and the condylar neck is elongated. The deformity is characterized by extreme facial asymmetry caused by the gross enlargement of the affected side, which produces a shift of the midline to the unaffected side. Since the maxilla grows in accommodation, there is a slanted plane of occlusion, being lower on the affected side. Hinds and Kent have provided a comprehensive classification of facial asymmetries, dividing these into two main categories: (1) unilateral facial overdevelopment and (2) unilateral facial underdevelopment, which will be discussed later. The condition to be discussed here is one of the more extreme types of unilateral overdevelopment. In differential diagnosis, benign tumors such as osteoma and chondroma should be ruled out.

Treatment of mandibular hypertrophy is complex, especially if the maxilla has become involved and must be subjected to surgery also. When the diagnosis is made early and interceptive condylectomy accomplished at an appropriate point in the development, maxillary osteotomy may be obviated. In fully developed hypertrophy, the maxilla must be raised, and this should be the first stage of treatment (see section on horizontal maxillary osteotomy for discussion of technique). Surgery on the mandible should follow in one operation, with condylectomy and ostectomy of the lower mandibular body on the affected side by an extended Risdon approach. Subcondylar (oblique) osteotomy in the ramus on the unaffected side may be necessary because it will permit freedom of rotation over to the affected side and up to the previously raised maxilla without putting the joint on the unaffected side into a torque relation. Preauricular approach to the condyle and intraoral degloving approach to the hypertrophied body have been suggested, but we do not favor either in treatment of this particular problem for technical reasons. The preauricular approach is anatomically limited, making removal of a mass the size of these hyperplastic condyles extremely difficult. Also,

since contouring the lower border of the mandible can be done more accurately and with less morbidity from an extraoral view, both it and the condylectomy can be done through the one opening. Among our objections, the most serious drawback to wide intraoral incision and radical "degloving" is that perioral musculature is frequently so severely damaged that facial expression is permanently impaired and thus a second deformity is created.

A brief review of procedure and technique is outlined and illustrated with three case histories showing the variables of the problem.

Case 1. A 36-year-old woman was referred by her dentist for evaluation and possible treatment of gross mandibular hypertrophy. The left side of her face was enlarged, and the midline was distorted to the unaffected side. A flattening of the affected side with bowing out of the ramus on the unaffected side was characteristic. Viewed obliquely toward the affected side, mandibular protrusion and the overdeveloped lower border were obvious. There was a 3 cm disparity between the lower borders of the mandible as measured on the lateral cephalogram. The massive size of the condyle hyperplasia is demonstrated best in a submental vertex projection.

Workup should include face bow transfer and mounting of study models on an articulator so that a correct maxillary plane of occlusion can be established. From this laboratory procedure an intraoccclusal splint is prepared for insertion when the maxillary osteotomy is accomplished. It is fixed between the posterior teeth on the affect side, and intermaxillary fixation is secured on both sides. In addition, a suspension wire is run from the zygomatic arch to further secure the maxilla in its raised position.

Treatment included maxillary surgery as well as the final mandibular procedure. The maxillary surgery in this case was in two stages, the palatal procedure preceding the second procedure by 19 days. Anesthesia was induced with methohexital (Brevital) and halothane (Fluothane) for both procedures. There was appreciable blood loss during the second procedure, but the patient did not receive a transfusion then. However, because of the unexpected development of anemia, she did receive a transfusion on the first postoperative day and had an allergic reaction to transfusion. Six days after the operation the patient became jaundiced, and 4 days later hepatitis was positively diagnosed. This complication occurred too soon to be attributed to the whole blood transfusion, and twice-used halothane was considered to be the cause. Because of this problem, the mandibular surgery was postponed indefinitely and a semipermanent removable prosthesis was provided for an interim functional occlusion in the interocclusal space. The normal maxillary occlusal plane was maintained through this waiting period. A Panorex film shows the intermaxillary space, well-healed maxillary osteotomy, aerated maxillary sinuses, and elongated hyperplastic left condyle. Normally the final mandibular operation would be scheduled 6 to 8 weeks after the maxillary surgery. In this case it was deferred 8 months.

The mandibular procedure that we prefer and that was used in this case is as follows:

1. A submandibular approach to the condyle area is accomplished in the usual way through a fairly long incision.

2. When the mandibular (sigmoid) notch is identified, a Thompson ramus retractor is installed, and the periosteum is further elevated, exposing the joint and as much of the condyle as possible. Strong distraction of the ramus using a bone-holding forceps clamped to the angle facilitates access. The condyle is freed as completely as possible prior to osteotomy.

3. A straightforward bur cut is made through the neck of the condyle beginning at the sigmoid notch and extending horizontally to the posterior border. If the situation warrants, the osteotomy can be completed with a chisel, but undesirable vertical splitting may result in a jagged uneven stump.

4. When the horizontal osteotomy at the neck is completed, the mandible is again distracted downward and a Kocher forceps is clamped onto the neck of the condyle. Rotation of the condyle permits access and visualization of the medial surface and further freeing of the condyle by blunt dissection. It is better to detach the lateral pterygoid muscle in this manner than to simply tear the condyle free from it, although there is a certain amount of disengagement by tearing in any condylectomy.

5. Once the condyle is removed, the depth of the wound is packed with hot, moist, gauze compresses.

6. Ostectomy of the hypertrophied lower mandibular body is then begun by scribing on the lateral surface a design for the cut using a No 703 carbide bur. It should not necessarily parallel the lower border, since the contour in hypertrophy is usually abnormal. It is important to carefully estimate the distance of the mandibular canal from the lower border and to try to stay just below this level.

7. If there is doubt about the location and level of the canal, decortication of the lateral cortex can be carried out and the course of the canal identified.

8. Usually the ostectomy is accomplished in a straightforward way, but the cut through to the medial cortex is completed with a smaller size bur (No 702 or No 701).

9. Since the hypertrophied side is usually flattened and deficient in lateral contour, even after condylectomy permits a swing to the affected side, the excised bone from the lower border may be saved and onlaid onto the lateral surface just above the newly created lower border. A plumping effect can thus be achieved.

10. If there is any restricting influence from the unaffected side a subcondylar (oblique) osteotomy should be done on that side at this time. Since this is usually necessary, access should be planned for in preparation and draping. The unaffected side should be draped in view anyway so that it is available for comparison as the ostectomy is designed and accomplished.

11. The jaw is immobilized for about 3 weeks, and then light intermaxillary elastic ligatures are maintained for another 2 to 3 weeks to guide occlusion and help develop a new and functional joint at the site of condylectomy.

Symmetry has been achieved in this care. The protrusion has been eliminated, and the contour of the mandible on the affected side is normal postoperatively. The line of the incision crosses the crease lines in the skin, but this was necessary for good access to the bone surgery. The patient had complete rehabilitation of her dentition and now has an excellent functional occlusion with a normal plane. The lower border of the mandible is equal bilaterally as viewed in a postoperative cephalogram. On the postoperative Panorex film the mandibular canal runs parallel and immediately adjacent to the lower border on the operated side. The patient had no nerve damage. A new functional articular surface has formed at the

site of condylectomy, and the patient can open her mouth to a normal degree with minimal deviation.

Case 2. A 55-year-old woman was referred by her dentist for correction of gross mandibular hypertrophy. The left side of her face was enlarged, and the midline was distorted to the unaffected side. There was the characteristic flatness of the affected side and the bowing out of the unaffected side. The long circular extent of the hypertrophied mandible was pronounced, and there was a slight protrusion. The maxillary plane of occlusion was slanted down to the affected side, but only modestly, and the dentition was generally poor. The posteroanterior skull x-ray film exhibited exactly what would be expected after examining the patient: (1) a grossly enlarged condyle with an elongated neck and (2) a long, flat ramus and body on the affected left side, deviated midline, and rotated unaffected right mandible. The typical grossly enlarged left condyle is again well visualized in the submental vertex projection. The treatment plan in this case did not include maxillary osteotomy, since the plane of occlusion was not that far off, and it was expected that a good functional occlusion could be provided by dental prosthesis and rehabilitationl. Surgery to correct her deformity therefore was accomplished in one operation. It included condylectomy of the hyperplastic left condyle, ostectomy of the hypertrophic lower portion of the left mandibular body, and free augmentation graft to the lateral surface using the excised lower border. Subcondylar (oblique) osteotomy was also done in the ramus of the right or unaffected side. The patient's postoperative appearance was symmetrical, her profile was normal, and the plane of occlusion was acceptable.

Case 3. A 23-year-old man was referred with the identical facial characteristcs and roentgenographic findings as those seen in Cases 1 and 2. The only difference was seen clinically in his occlusion. He had an open bite on the right side with a slanted mandibular occlusal plane and early cross bite on the left. The maxilla was level and had not, as yet, tended to accommodate by growth downward on the affected side. Treatment included removal of the hyperplastic right condyle and excision of the hypertrophic lower border of the mandibular body - all through a submandibular incision. Preoperative plans included simple vertical osteotomy in the left ramus, but this was not done since perfect occlusion occurred after the condyle was removed. Immobilization was by intramaxillary loop wiring for 3.5 weeks, after which function was encouraged and light "guide elastics" were used on the normal left side only to aid in establishment of a new articulation in the area of the temporomandibular joint. This light elastic guidance was continued for 5 additional weeks. Normal function developed as well as normal facial symmetry.

The treatment of these rarely seen and difficult problems is interesting. The results are more certain and gratifying than those obtained in the other extreme asymmetrical condition of agenesis described later. Perhaps as more of these unusual deformities are treated and reported, more knowledge will be available and better service can be provided.

Micrognathia and Retrognathia

A distinction should be made between *micrognathia* and *retrognathia.* Micrognathia is defined as abnormal smallness of the jaw, especially the lower jaw, whereas retrognathia simply implies a retruded position (Angle's Class II) of the mandible without diminution. Another term deserving definition is *microgenia,* or abnormal smallness of the chin. Surgical correction of the micrognathic mandible has always been a more difficult undertaking than correction of prognathic deformities. Two principle reasons account for the difficulty: (1)

bony substance in which to perform osteotomy is minimal, and (2) availability of investing soft tissue to cover the surgically elongated jaw may also be less than adequate or desirable.

An ideal surgical technique for correction of mandibular micrognathism should provide (1) improved acceptable occlusion of the teeth into Angle's Class I relation, (2) cosmetic benefits, including mental prominence and pronounced gonial angle, (3) psychological benefits, (4) improved phonetics, and (5) technical feasibility including (a) adequate bone contact at site of osteotomy to ensure bony union, (b) minimal or no injury to important anatomical structures such as contents of mandibular canal, (c) surgical repair and closure assuring no permanent disruption of function, and (d) reasonable operating time.

Innumerable operations have been suggested for the correction of this deformity. Blair, in his article published in 1907, advocated oblique section of the ramus at the level of the mandibular foramen. In 1909 he reported two cases treated in that manner. In 1928 Limberg reviewed the literature on this subject. At that time a number of methods had already been advocated for osteotomy and forward repositioning of the mandible in micrognathia. He proposed a "step" operation in the body of the mandible, wuth the addition of a rib graft. He credited Pehr Gadd (1906) with the original conception of the principle of step sliding osteotomy in the body of the mandible, which was commonly employed in correction of micrognathia or retrognathia. In 1936 Kazanjian described an L-shaped sliding osteotomy that is suitable for correction of the deformity also. This and the step procedure were the principal operations used up until the mid 1950s. If teeth are present in the ridge posterior to the proposed location for osteotomy, the L-shaped incision in the bone was preferred, since bony contact could be assured. Obwegeser suggested vertical (sagittal) splitting of the posterior body of the mandible anteroposteriorly through the lower portion of the ramus and gonial angle. Caldwell and Amaral and Robinson modified the vertical ramus osteotomy used in prognathic cases and added iliac bone to permit advancement of the mandible. This mortised inlaid onlay of autogenous bone provides desirable additional substance. The procedure is indicated in selected cases and will be discussed in further detail. Thoma suggested using a rib graft instead of iliac bone. When more prominence at the gonial angle is desirable, he recommended securing the rib with attached cartilage from the costochondral junction, since projecting cartilage at the gonial angle will not resorb as does bone. Robinson and Lytle reported 14 micrognathic patients surgically corrected by the same vertical (or oblique) section in the ramus, but bone was not added. Wire sutures were inserted to ensure bone contact and union. This is similar to the procedure that Limberg reported in 1925 for correction of open bite deformity. In view of the newer vertical L or C osteotomy, this simple vertical osteotomy of Robinson's is not recommended because of the minimal bony contact, loss of gonial angle, tendency to distrate the condyle head, and regression. In 1968 Caldwell, Hayward, and Lister presented a new approach to this difficult problem and with their methods have eliminated to a great extent many shortcomings and technical difficulties encountered heretofore in the previously accepted standard operations. Details of the surgical technique will be described later in the text. This technicue more nearly satisfies criteria for an ideal surgical approach for correction of either micrognathia or retrognathia. In 1973, however, Hayes reported modification of this proceudre by "sagittal separation in the inferior region of the body of the mandible". We agree that sagittal osteotomy as he suggests "produces better bone contact than the 'C' osteotomy and is technically easier than the intra-oral sagittal procedure". We have adapted this modification to our techniques and recommended its general acceptance. Details are included later in the text.

Preparation for surgery

Planning of surgery for the correction of micrognathia must be meticulous and detailed. The workup should follow the outline found above. The cardboard templates are made from cephalometric roentgenograms.

Since the body of the mandible in micrognathia is smaller than normal, when osteotomy is contemplated in this area, it must be determined that a sufficient bulk of bone exists to afford ample apposition of bone and union. The mandibular notch anterior to the gonial angle is often accentuated, and it is the vertical dimension from this area to the apices of the molar teeth above that may limit use of L or C osteotomy. This vertical dimension can be determined by use of cephalograms and the Panorex x-ray film; however, there is no way to accurately measure the *mediolateral thickness* of the mandible, and for that reason, sagittal splitting as suggested by Hayes may be impossible because of the thinness of bone at the planned location for osteotomy. When splitting is in the preoperative plan, but on exposure, the bone is found to be so thin that splitting may result in unplanned fracture, the standard L osteotomy may be resorted to as an alternative.

There is infrequently an indication for step or "sliding L" osteotomies in the body of the mandible; however, the need may arise in rare cases. Apposition of bone along the horizontal cut can be assured as the mandible is moved forward in step or L osteotomies in the body of the mandible if no teeth are located posterior to the vertical incision in the alveolar ridge. However, if teeth in the proximal (posterior) portion occlude with maxillary teeth, an appreciable space may result between the cut fragments. Plans for a step operation should be discarded if it is evident that bony contact between the cut sections will be inadequate for union to occur. Addition of autogenous bone chips from the illium affords one solution; however, selection of another operation is better.

If the lower third of the face is exceptionally tiny, ramus osteotomy with addition of iliac bone or rib should be considered. If the bulk of the bone seems to be adequate, the L or C osteotomy in the rami is no doubt the method of choice, especially if sagittal splitting of the body portion can be a part of the plan.

Technique for step sliding osteotomy. It has been suggested that this operation be done in two stages on the premise that there is less likelihood of creating a compound wound into the oral cavity and that chances for injury to the mandibular nerve are minimized. This is a suggestion worthy of consideration, even though it is exceedingly difficult to avoid injury to the mandibular nerve. Also, because periosteum is inelastic, it is inconceivable that the mandible can be elongated in this step sliding osteotomy without interrupting the continuity of the oral soft tissues at some point, either by frank laceration or detachment of gingival margins. It is recommended that step sliding osteotomy be performed in one operation, following essentially the same technique as described for ostectomy in correction of mandibular prognathism. Exceptions to that technique and other considerations include the following:

1. As a rule the whole procedure can be accomplished by an extraoral submandibular approach; however, preparation of skin and draping should include the oral cavity and curtain draping, since splinting and intermaxillary immobilization must be attended to when the osteotomies are completed.

2. The incision must be of sufficient length to permit access without undue trauma to the soft tissues; however, if deeper tissues and periosteum are opened sufficiently to allow for instrument manipulation, the skin incision may be kept to 4 or 5 cm in length.

3. The Stryker reciprocating saw and a No 702 carbide fissure bur are used to make the vertical cuts.

4. A horizontal cut is then carried posteriorly, paralleling the plane of occlusion. The Stryker oscillating saw with a 3-mm blade or burs are employed for this purpose. If the inferior alveolar nerve is cut or otherwise injured it usually regenerates.

5. Final separation of the bone through the cuts may be facilitated with a thin, flat chisel and mallet or simply by placing the edge of a Lane periosteal elevator into cuts and prying the bone apart gently. Frequently, incompletely severed areas can be freed in this manner.

6. At this point the mouth is entered and the teeth are fixed into occlusion, which has been previously determined. It is essential that splints or orthodontic appliances be planned. The connections that have been arranged are placed to stabilize the sectioned dental arch.

7. The intraoral instruments are discarded, gloves are changed, the curtain drapes are readjusted to expose the surgical field, and the paralleled edges of the horizontal cuts are wired together.

8. Closure and dressings are as previously described.

Horizontal L sliding osteotomy. Horizontal L sliding osteotomy is a variation of the step operation that has just been described, and it is performed in essentially the same manner. However, if this design is ever indicated it is better to discontinue the horizontal cut anterior to the angle and complete the osteotomy with a vertical step that will leave the prominence of the gonial angle for a better esthetic result.

The principle of step operations to secure elongation of the mandible may also be utilized to correct other abnormalities in jaw relationship. For example, the patient had a Class I jaw relation, but with no occlusion of teeth. The entire mandibular arch was in lingual version to the maxillary arch, with contact of buccal surfaces of the lower teeth to lingual surfaces of the upper teeth. At one time the patient had gross anterior maxillary protrusion, but when we first saw the patient, an effort had been made to correct this cosmetic problem with a six-tooth anterior bridge. The step operation was used in this case to *widen* the mandible.

Vertical osteotomy in the rami with bone grafting

In 1954 Caldwell and Letterman predicted that modification of vertical osteotomy as it is utilized in correction of prognathism would also make possible correction of micrognathia. In 1960 the technique was completely described. The principles of vertical section in the ramus, coronoidotomy, and decortication are applicable in this operation. The objectives are (1) separation of the ramus vertically from the mandibular notch to the lower border of the mandible at the angle in a line over or just posterior to the mandibular foramen, (2) angular section of the coronoid process from the mandibular notch obliquely downward and forward to the anterior border to permit forward repositioning of the distal fragment

(body and anterior ramus) without interference, (3) decortication of the lateral cortex over a broad area of the lower aspect of the ramus as a recipient area for bone graft, (4) movement forward of the distal (body of the mandible) fragment to the desired occlusal relation, (5) interposition between the fragments and onlay into the decorticated area of a measured full-thickness block section of bone from the crest of the ilium.

Technique for vertical osteotomy in the rami with bone grafting. The basic approach is similar to that for prognathism.

1. The patient is prepared and draped in the manner already described. In addition, the pubic area is shaved the day before, and the iliac donor site is prepared and draped for the removal of the bone for grafting.

2. The lateral aspect of the ramus is exposed in the manner already described, and the prominence of the mandibular foramen is identified.

3. A vertical cut is made from the mandibular notch to the lower border of the mandible as described for vertical osteotomy in prognathism, and the coronoid process is also detached in the same manner.

4. The course of the mandibular canal from the foramen downward and anteriorly is estimated and so marked with a surgical marking pen.

5. Multiple drill penetrations are made into the lateral cortex from the mandibular foramen and the estimated level of the mandibular canal to the lower border of the mandible. They are extended from the posterior border to a point approximately 2 cm anterior to the verical cut in the ramus.

6. The lateral cortex is removed from this broad area with the flat, long-beveled Stout No 3 chisel, creating a flat surface onto which the bone graft will subsequently be fitted. Care should be taken not to injure the inferior alveolar nerve during the decortication, but it should be identified so that it can be avoided when the vertical section is completed.

7. The wound is packed, the patient's head turned, and the procedure just described repeated on the other side.

8. By this time the surgical team that is to obtain the graft should be started.

9. The procedure on the second side is completed except for fitting and placement of the graft.

10. The vertical sections are completed on both sides, following the techniques described for the treatment of prognathism.

11. It will be found that the mandible and anterior portion of the ramuse are easily repositioned anteriorly. The mouth is entered, and intermaxillary elastic ligatures are placed to fix the teeth into desired occlusion. Arch bars wired to all teeth should be utilized because heavy traction must be placed to ensure maintenance of teeth in proper occlusion during the manipulation necessary to inlay the bone graft.

12. The length of the section of bone needed can be measured with accuracy by calculating the replacement. It can be cut accurately, also, if an assistant holds it securely on a wood block while the surgeon sections it to the desired size with the Stryker oscillating saw. The full-thickness portion of the graft must be tapered to a lesser width to fit superiorly, since the void to be filled is less superiorly than at the lower border. The full thickness of the graft with both cortices remaining serves to maintain the elongation of the mandible, and union of the well-mortised graft occurs in about 8 weeks.

13. Once fitted into the voids, the graft is wired onto the decorticated bed with fine stainless steel wire sutures (0.016 inch).

14. Scraps of medullary bone that have been saved during trimming of the graft are added in the void above the block inlay and in any other spaces not filled or in close contact.

15. Closure and postoperative care are the same as previously described.

Discussion. There are two objections to this procedure that cannot be circumvented. First, it is a long operation, requiring 4 to 5 hours. However, with the patient adequately supported during and after the surgery, the course is ordinarily uneventful. The second objection concerns use of the ilium for the donor site. Patients always complain much more about the hip than the jaw. "Bank" bone is not believed to have the potential for a "take" that autogenous graft have.

Results in cases of micrognathia treated by this method have been so successful that the principal disadvantages just mentioned can be accepted. By comparison to other methods, the operation has the following advantages:

1. It is adaptable to the usual cases of micrognathia.

2. As much as 1 to 2 cm of advancement can be secured.

3. The small size and bulk of the body of the mandible are not contraindications.

4. Firm clinical union is rapid, requiring about 8 to 10 weeks.

5. The cosmetic result is excellent because the angle of the mandible is maintained or improved at the same time the body is advanced to provide a good profile.

6. The operation can be done without injury to important nerves (that is, mandibular and facial).

7. Elaborate splints are not needed. Orthodontic appliances or ordinary arch bars will suffice for fixation during the period of immobilization.

An acceptable substitution for this iliac bone graft procedure is one described by Thoma. A rib graft does not provide the bulk of bone substance obtained by onlaying with a block from the ilium; however, it is easier to obtain and is less disabling for the patient. The surgical technique is the same as described for placement of iliac bone. Edges of the rib graft are perforated with a drill to afford medullary bone contact when it is interposed between the proximal and distal parts to obliterate the space created as the distal (body portion) is advanced.

Vertical L, L modified, or C sliding osteotomy (without bone grafting)

When there is no need for the addition of bulk in correction of retrognathia (micrognathia is not a factor) but simply an advancement of the mandible to Class I relation is desired, the vertical L sliding osteotomy (or modified) is an excellent procedure and one to be considered.

1. This operation is accomplished by an extraoral submandibular approach, using curtain draping to permit access to the oral cavity for intermaxillary immobilization.

2. The incision should be about 5 to 6 cm in lenght to ensure adequate access to the whole lateral surface of the ramus and several centimeters of the lower border of the mandible anterior to the angle.

3. The outline of osteotomy should be scribed on the lateral surface of the bone as preplanned from tracings of a lateral cephalogram. This line of osteotomy may be vertical down from the mandibular notch or horizontal from the anterior border of the ramus above the mandibular foramen and then vertically down, to within about 1.5 cm of the angle of the mandible. The *line of fuct is then curved anteriorly* and may be extended in this direction as far as necessary to allow for necessary "sliding" advancement of the jaw and to maintain bone apposition on the horizontal plane at the lower border of the mandible. A third line of osteotomy may be in the shape of a C circling around the mandibular foramen from the anterior border of the ramus to the angle of the mandible and then anteriorly, as already described. Lister used this C cut.

4. If a straight vertical cut from the mandibular notch is planned, coronoidotomy should be accomplished to eliminate interference of the temporal muscle with the forward placement of the mandible.

5. Osteotomy is accomplished as usual, with much care exercised in the parts of the cut above the mandibular foramen, since "guarding" on the medial surface is technically not feasible. We depend on 18.000 rpm, sharp bone drills and the sense of feel to ascertain lack of resistance as penetration of the medial cortex occurs. Points of incomplete osteotomy are severed using short, sharp taps with a broad-bladed, sharp chisel and mallet.

6. From about the height of the mandibular foramen on down parallel to the posterior border of the ramus and anteriorly parallel to the lower border, the osteotomy can be accomplished rapidly, since medial soft tissue may be guarded with a broad, flat Lane periosteotomye. A No 702 or 703 carbide fissure bur in the Jordan-Day engine is used to take advantage of the side cutting effect. As the cut is extended anteriorly parallel to the lower border, it is first scribed into the lateral cortex using one of the larger burs, and then the osteotomy is completed through the medial cortex with a No 701 carbide bur. This results in minimal bone excision and reduces chance of injury to the neurovascular bundle.

7. When osteotomies are completed on both sides, the mouth is entered, and the new occlusion relation is fixed by heavy intermaxillary elastics. A clear acrylic "wafer" occlusal guide plate is more routinely used in retrognathic cases.

8. After a change of gloves the curtain drape is readjusted, and the surgical field is reentered. Freedom of the proximal fragment (posterior ramus and condyle part) is ensured from muscle binding. Bone approximation is checked along the horizontal cut above the lower

border. At least one wire suture is placed on each side to ensure proper bone fragment control.

9. Closure of soft tissue follows a standard technique.

An addendum is necessary here. The patient previously reported on has since been followed up. Her first operation was in March, 1965, at age 14. Orthodontics had been planned in conjunction but was not accomplished. Regression occurred. A protrusion habit developed in a subconscious effort to compensate for the regression. When seen with this result in November 1969, 4.5 years postoperatively, the patient was satisfied and rejected a suggestion for reoperation. She had *acquired* a normal Class I relation of the jaw but without posterior occlusion. No doubt the condyle resided well forward of its normal position in the glenoid fossa most of the time. By 1972 the patient, then 20 years old, had developed an acute temporomandibular joint arthritis produced by her protrusion habit and abnormal joint relation. She accepted surgery to overcome the problem. Much has been learned from this case as summarized in the following:

1. It is reiterated that vertical L sliding osteotomy or a modified version is an excellent operation for the correction of retrognathia.

2. In micrognathic conditions, autogenous bone grafting should be considered and is recommended.

3. Best results can be expected when treatment is carried out with orthodontic support.

4. Overcorrection should always be attempted, since there is a strong tendency for regression to some degree.

5. The condyle head must not be distracted from the glenoid fossa during surgery when the distal (mandibular body) portion is advanced. Special care must be taken to secure it snugly inthe glenoid fossa. Transosseous wire is directed so that pull is toward the proximal fragment.

Modified L or C osteotomy of the ramus and sagittal osteotomy of the mandibular body

Hayes suggestion for sagittal osteotomy in the body of the mandible as a modification to L or C osteotomy is a significant improvement over the technique that has been described in the immediately preceding pages. Byrne and Hinds have endorsed this modification after using it in seven patients. They state that "criteria for technical feasibility including simplicity, surgical repair, operating time, function, preservation of anatomic structures and bone healing have been satisfied in this procedure" and further "that this operation possesses the advantages of the 'parent' procedures without the major disadvantages of either". This is a reference to the extraoral L or C osteotomy and the intraoral sagittal ramus procedure. Fox and Tilson also endorse the Hayes' procedure as offering significant advantages in treatment of mandibular retrognathia and also suggest that the tendency toward relapse can be reduced by installing the coronoid process in the vertical void as a free bone graft. Hayes had suggested sliding a graft of lateral cortical bone posteriorly from the anterior portion of the ramus.

We are also pleased with the results in the several cases in which we have used this *body sagittal split.* We have, however, encountered one patient in whom the mandible was

so thin that the conventional L procedure was utilized as an alternative at the time of surgery. Unfortunately, cephalograms and panoramic x-ray studies do not provide information on the *mediolateral* thickness of the bone. Our adaptation of the sagittal separation has varied somewhat from that reported by Hayes.

1. The vertical cut on the lateral surface is originated at the mandibular (sigmoid) notch and carried downward to a point just posterior to the mandibular foramen. It is then extended parallel with the posterior border of the ramus to within about 1.5 to 2 cm above the angle of the mandible. The cut from this point is made in the lateral cortex only and is curved anteriorly on the body of the mandible as far anteriorly as planned. This horizontal cut in the lateral cortex may be *over or even superior* to the course of the mandibular canal.

2. The *medial* cut is made *from the angle or even above it* obliquely up and anteriorly to the point where the cut on the lateral surface curves. Thus an extensive approximation of bone is achieved as the bone is split and sagittal sliding osteotomy occurs.

3. All bone cuts are made using burs ranging in size from No 703 to 701. The cut on the lateral surface is started with a No 703, which affords better control of penetration of the cortex without risking injury to the nerve. Cuts above the foramen and from the horizontal cut through the lower border are made with a No 702. The vertical oblique cut on the medial surface is made with a No 703, while the cut through the cortex along the lower border is done with a No 701.

4. Final separation may require use of the broad No 3 Stout chisel or any broad thin osteotome. The nerve should be intact as separation occurs, even though the lateral cortex is raised, exposing it. Hypoesthesia is uncommon but may result from stretching as the distal (body) segment is repositioned anteriorly.

Summarizing, we have found sagittal splitting of the body portion of the osteotomy to be a marked improvement in this L technique and have lengthened the mandible as much as 2 cm in one case. We prefer the L shaped cut in the ramus to the C but believe coronoidotomy is essential to ensure against relapse. When grafting is indicated, we usually install fresh autogenous rib since the morbidity from taking it is less than when the ilium is used as a donor. This type of graft is preferable to either the coronoid process or the lateral cortex since neither of those donor sites yield medullary bone. Medullary (cancellous) bone will hasten repair and regeneration of new bone in the vertical void while free grafts of cortical bone are less apt to survive, and the density of free grafts is unnecessary as a "strut" to maintain the advancement. To date, we have encountered one patient whose mandible was too thin for splitting without risking unplanned fracture.

Z osteotomy

One variant from the usual type of retrognathia is characterized by Class I malocclusion, deep anterior overbite, remarkably decreased anterior vertical dimension (N to Pog), abnormally pronounced labial mental crease, extremely square mandibular angles, and unusual breadth in the lower third of the face. The basic problem is that of a retruded mandible, but the facial and skeletal composition places a new requirement for surgical correction. Two case histories and a method of surgery are described and will be summarized herein.

In treating the first patient, there appeared to be three principal objectives: (1) elongate the mandible to correct the Class II relation; (2) increase the N to Pog dimension and eliminate the overbite and at the same time improve the profile; and (3) reduce the prominent gonial angles to overcome the square-faced appearance.

L and C osteotomy designs were not applicable; however, further experimentation with "paper cutouts" suggested that a Z-shaped design was adaptable, and all objectives appear to be achieved. From this first design a modification has developed, resulting from technical problems with the horizontal cut above the foramen that extended to the anterior border of the ramus below the coronoid process.

Technique of the Z osteotomy

1. The conventional Risdon approach to the ramus of the mandible is used. When the entire lateral surface of the ramus is exposed, a Thompson retractor is hooked over the mandibular (sigmoid) notch.

2. Coronoidotomy is accomplished in the standard way.

3. The prominence of the mandibular foramen is identified, and the approximate route of the mandibular canal is judged by comparison of the Panorex x-ray film to the lateral surface as it is viewed.

4. With the course of the canal in mind, a curving line is scribed from the mandibular notch vertically downward and back of the foramen and then curving down and forward just below a route judged to be that of the canal.

5. At a point anterior to the antigonial notch and several millimeters above it, the course of the bone cut is reversed at an acute angle and carried horizontally to the posterior border of the ramus, again several millimeters above the angle. The design for this osteotomy as presently used is shown.

6. An interocclusal splint or "wafer" should be available to install between the arches as the mandible is advanced to the desired new position. This is to prevent uncontrolled extrusion of posterior teeth during the period of immobilization and also to ensure placement of the mandible into correct relation with the maxilla.

7. Modest decortication and mortising at some points on both aspects of the Z incision may be necessary to ensure good bone apposition. Small transosseous wire sutures are placed on each side.

8. The jaw should be immobilized for about 6 weeks.

In both cases the results are good at present and seemed to have warranted this tedious procedure. Descriptions of these cases illustrate the problem and the reasoning for the procedure.

Microgenia and Genioplasty

Osteotomy and advancement or lengthening the mandible is not always necessary in receding "Andy Gump" facies. Occasionally the occlusion is satisfactory, and all that is

needed to improve appearance is addition of substance to the chin or rearrangement of bone already present. At the same time much psychological benefit can result. Occasonally genioplasty is adjunctive to the cosmetic result after one of the previously described osteotomy procedures. Bone, cartilage, tantalum mesh, and allopastic materials have been used to build out the mental prominence. Intraoral or extraoral access to the chin is obtained, depending on indications and treatment plan.

The least complicated approach to treatment of this problem is by implantation of a contoured-to-measure piece of silicone rubber inserted intraorally. A short, vertical incision is made at the midline, through which a pocket is formed by blunt dissection. The implant is inserted and properly positioned, and after closure of the wound a semipressure dressing is carefully placed over the chin and lower jaw to maintain the implant in proper position during the immediate postoperative course. Other foreign materials are also "pocketed" supraperiosteally.

The report of Robinson and Shuken in 1969 was discouraging. They reported that 12 of 14 patients with chin augmentation by plastic implants showed some degree of bone resorption on postoperative radiographic follow-up. They recommend a routine procedure for follow-up examinations but do not discourage continued use of this procedure for genioplasty. Silastic implants also tend to be expelled as does cartilage.

Most of the techniques for genioplasty just mentioned have limitations. Alloplastic materials have a tendency to migrate from the position in which they are placed at the time of surgery. Erosion of the chin prominence contiguous with the implant has been reported. Patients have also reported unpleasant sensations in the implant region when they were exposed to cold temperatures. We recently removed a Silastic implant device that had migrated into the mental region.

Probably the best way to enlarge the prominence of the chin is to reposition the lower border anteriorly by osteotomy. In 1958 Obwegeser suggested a horizontal sliding osteotomy of the anterior lower border of the mandible that was a modification of Hofer's earlier procedure.

Augmentation and reduction genioplasty (intraoral)

The intraoral procedure for augmentation and reduction genioplasty is as follows:

1. A paragingival incision is made from the second premolar tooth to the second premolar tooth on the opposite side of the arch.

2. The chin prominence is degloved by elevation of the periosteum anteriorly between the mental foramina.

3. The midline is recored by scoring the bone with a fine bur in the midsagittal plane across the area of the planned osteotomy.

4. A horizontal osteotomy cut is made in a plane established by three points. The posterior points are set 3 mm below the mental foramina. The anterior midline point is set 2 mm superior to the point of greatest chin prominence.

5. The osteotomy is continued through to the medial cortex with the oscillating Stryker sawblade.

6. The segment is freed of all its attachments.

7. The segment is then placed in the preplanned position and fixed with three transosseous wires, each of which engages the medial cortex for the segment and the anterior cortex of the mandible.

8. The incision is closed, using No 3-0 polyglycolic suture material (Dexon) in a continuous horizontal mattress format.

9. A pressure bandage is fashioned by placing a folded 10 by 10 cm gauze sponge over the inferior lip, and this is secured with a piece of 2.5 cm tape placed circumferentially around the chin and neck.

This versatile procedure may be modified to correct many deformities of the chin prominence. Abnormally prominent chins may be reduced in size and contour by sliding the segment posteriorly. A narrow, more finely contoured chin may be created by sectioning the segment in the midline and removing a wedge-shaped piece. The length of the lower one third of the face may be reduced by removing a wafer-shaped section superior to the original osteotomy, discarding it, and replacing the segment in the more superior position. Extreme retrusion of the chin may be corrected by using the wafer-shaped section just mentioned as an intermediate between the segment and the mandible. Thus the wafer is wired in a more anterior position, and the segment is wired to it. Corrections between 15 and 20 mm may be secured with this technique.

Augmentation and reduction genioplasty (extraoral)

Essentially, the same changes in bone contour at the lower border of the mandible anteriorly as have been described in the preceding section can be accomplished by an extraoral approach. The extraoral procedure has the advantages of sterile surgical technique avoiding contamination by oral secretions, excellent visualization of the operative site, greater ease of instrumentation, and less postoperative morbidity (edema and ecchymosis), while the only disadvantage is the skin incision and resulting scar.

The incision is made in a curve following the shape of the lower border of the mandible, and dissection is made through each subcutaneous layer so that closure can be achieved with minimal scarring. If there is scarring, it is under the lower border and not visible. The wound is closed in anatomical layers as dxescribed for other extraoral operations; however, a pressure dressing is applied to aid in maintaining the segments of bone in position even though transosseous wiring is used.

If large onlays of autogenous bone are needed, an extraoral approach is much preferred and probably safer. The case illustrated required placement of bone over a large portion of the right lateral surface of the mandible well back of the mental foramen as well as over the symphysis. The incision here was a long one placed well under the shadow of the mandible for two reasons: (1) to place the scar inconspicuously and (2) to have the line of incision well away from the bone graft so that the graft will be well supported. It should be noted in this case that the foreshortened, deformed side was the *left* side, but bone was added to the *right*

side and symphysis to develop a symmetrical face. Deformities of this type are ideally corrected in this manner.

Onlay grafts present other problems. If autogenous material is selected, a second surgical site is required from which to take the material. Bank bone or cartilage does not afford the predictability for a good viable graft. Furthermore, the placement of autogenous bone or cartilage grafts requires the use of an extraoral route for placement because of the difficulty of intraoral closure over graft material. A scar results, but placement of the incision well under the symphysis makes it acceptably obscure.

Arrested Condylar Growth

Arrested condylar growth causing mandibular agenesis (incomplete and imperfect development) to a marked degree, more severe than that seen in the ordinary retrognathic and micrognathic conditions, is rare. Because of this rarity there has been little opportunity to study the problem statistically or in a controlled manner. Variations exist in definition of different entities, and etiology is not entirely clear in all conditions. Similarly, there is not much experience in treating some of these conditions, especially those occurring in the first arch syndrome. For treatment planning purposes, Hovell divides mandibular agenesis into two main etiological groups: (1) those conditions caused by a localized disturbance inthe condyle growth center and (2) those conditions that are prenatally determined and part of the first arch syndrome.

Mandibular agenesis of the first group may have its onset prenatally or postnatally and may result from several causes, such as intrauterine compression, injury at birth and subsequent trauma, or infection. The deformity is primarily in the mandible itself in these cases, and for this reason the affected side or sides have a characteristic shape that, according to Hovell, "is absolutely diagnostic of a localized condylar growth disturbance". He attributes the development of this characteristic shape to normal adjacent investing tissues, which in normal molding and growth process exert normal stresses, but to the mandible with arrested growth these normal stresses cause growth dysplasia. This characteristic appearance includes (1) proclination of the lower anterior teeth and dentoalveolar structures, (2) prominent gonial angle, (3) pronounced antigonial notching, (4) shortened anteroposterior dimension of mandibular body, and (5) shortened vertical ramus and variable abnormal growth patterns in the coronoid process, sigmoid notch, and condyle. We have observed this same characteristic appearance in our cases and note a distinct difference between these and cases of agenesis occasioned by other causes. However, when this retardation or cessation of condylar growth occurs, it results also in extreme maxillary overjet and canting of the occlusal plane in unilateral cases, with a decreased pupillary line to occlusal plane distance on the affected side. Normal excursions of the mandible are not possible because of the lack of function of the lateral pterygoid muscle, which inserts into the anterior surface of the condyle and the articular disk. In young patients, this results in repeated subluxation of the condyle on the normal side when maximum mouth opening is attempted. Lateral excursions toward the normal side are impossible. Only minimal protrusion is possible, and attempts at protrusion result in deviation toward the affected side.

Except in cases of ankylosis, the surgical care of developmental problems associated with localized disturbance in the condyle growth center follows the methods described later.

Ankylosis

Ankylosis of the temporomandibular joint will be discussed now, since the principal etiological factor is interference in some manner with the condyle growth center. Ankylosis untreated during the formative years invariably results in agenesis. Ankylosis may be partial (fibrous) or complete, with bony fusion of the condyle head to the glenoid fossa area of the temporal bone. Fortunately, the majority of patients with ankylosis seek help before complete bony ankylosis occurs. They have a minimal degree of opening, usually in the range of 5 to 7 mm, and x-ray examination will show a broad, flat, irregular vestige of a condyle head. Also an irregular radiolucent line is seen, representing the line of fibrous cleavage, which permits whatever the degree of opening there may be. Above this irregular radiolucent cleavage line and immediately below it at the articular surface of the distorted condyle head, irregular radiopacities are seen in varying degrees.

Historically, treatment of ankylosis has ranged from condylectomy to various arthroplastic procedures, including installation of cartilage, dermal grafts, fascia, alloplastic materials, metal caps, and combinations of foreign substances. In patients afflicted with complete bony ankylosis, there is no choice but to establish a surgical juncture immediately below the mass of dense bone in the former joint area and instal a foreign substance such as a Silastic block to prevent reunion. Any technique that will assure mobilization and return to function is satisfactory.

Treatment of partial (fibrous) ankylosis, *especially in children, is entirely different.* Much growth potential is present in the characteristically deformed condyle head, and it must be preserved; however, function is necessary to activate this potential. For years, we have attempted to treat this problem by dissecting through the fibrous cleavage line until complete mobility of the area was established *and then proceeding* with condylectomy and arthroplasty, whether the patient was an adult or a child. We recently reported a case of bilateral ankylosis in a 7-year-old boy who was treated in this manner except that condylectomy was *not* included. Instead, sheet Silastic was capped over the deformed condyle head and in the line of cleavage. Eight years after surgery the patient can open to 35 mm, and his mandible is growing normally. The operative procedure was carried out bilaterally at the same time, which is essential to successful treatment when both sides are involved. It was done through routine Risdon approaches. The preauricular approach is not suitable for these procedures for numerous reasons. Exposure of the entire lateral aspect of the ramus was achieved including the coronoid process, sigmoid notch, deformed condyle, accentuated antigonial notch, and prominent gonial angle. The fibrous cleavage line was located and dissection through it carried out using sharp No 4 Molt curets and heavy manual pressure followed by elevation with a Lane periosteotome, distraction at the angle of the mandible (a good reason for the Risdon access), and leverage by an assistant at the symphysis. Both sides are opened so that access to both joint areas is available at any point in the operation. Total mobilization, with every vestige of intervening fibrous tissue severed, is essential so that enough completely free space can be created in the cleavage area to slide a sheet of Silastic over it to the medial surface and to secure it in a caplike effect over the whole condylar process. It is a difficult undertaking but worth the effort in children if by the procedure the growth center can be preserved, function established, and development permitted to occur normally. The case described has the longest follow-up; however, other children treated since then appear to be developing normally also.

In addition to the actual operative procedure, the following factors must be considered:

1. Anesthesia must include plans for blind nasotracheal intubation, which requires a skilled anesthesiologist, or presurgical tracheostomy as an alternative route to anesthesia.

2. Blood loss may be significant at the time of surgery, especially in children, and there should be plans for replacement if needed.

3. Immediate postoperative tissue reaction should be kept to a minimum by use of steroids such as dexamethasone (Decadron), antibiotic coverage, and ice packs. Antiemetics and analgesics as required and good general supportive care should be prescribed as indicated.

4. Immediate postoperative function is essential to ensure against recurrence of the ankylosis. This is achieved by forced exercise or exercise while the patient is under analgesics. Gum chewing and biting on spring-type clothespins are prescribed in the long course of a regular scheduled program.

The first arch syndrome

As noted previously, the second of Hovell's main etiological groups is mandibular agenesis that is prenatally determined and merely a part of a wider syndrome - *the first arch syndrome* (oral-mandibular auricular syndrome). Because of clinical features, anatomy, and embryology, the following anomalies of the head and neck are considered by McKenzie to arise from abnormal development of the first branchial arch and should be included in this first arch syndrome: (1) Treacher-Collins syndrome (mandibular facial dysostosis), (2) Pierre Robin syndrome (hypoplasia of the mandible with glossoptosis), (3) mandibular dysostosis, (4) cleft lip and palate, and (5) hypertelorism and others. Obviously a multiplicity of developmental skeletal deficiencies are included such as agenesis of the mandibular condyle and hypoplasia of other facial bones, especially the malar, as well as a host of overlying soft tissue malformations, such as macrostomia, auricular deformities (microtia), antimongoloid obliquity of the palpebral fissures, and decreased orotragal and canthotragal dimension. Some of these deformities arise from abnormal development of the second branchial arch as well as the first.

These deformities are challenging problems to anyone interested in reconstructive surgery; however, the oral and maxillofacial surgeon's interest is directed principally to the jaws and dental apparatus. If a deformity in the mandible affects growth in the maxilla, the oral surgeon's interest should extend to that area and so on. Most authorities agree that surgical intervention should be undertaken early and staged as necessary, the philosophy being that if skeletal growth does not occur in a normal way, then soft tissues will also not grow normally; however, if skeletal enlargement is achieved surgically, then investing soft tissue will grow to accommodate and normal development on the affected side may be maintained. Contrarily, it is well known that scarring is a normal sequela to surgery, and therefore, when serial bone grafting is staged over the years of development, soft tissue scarring can be expected that in turn may inhibit bone as well as soft tissue growth to some degree.

Surgeons who have endorsed this approach perform serial bone grafting with split rib onlay grafts, since the rib cage is a bank of autogenous bone that will replenish naturally. *The iliac crest with its growth center should not be used as a source of bone in children.* Cartilage, banked bone, and dermal grafts have also been used to fill in defects. Stark and Saunders have used bone homografts in patients as young as 18 months. Longacre and

associates prefer to start reconstruction before the child is 4 years old to prevent personality and behavior problems. Experience and enthusiasm for early serial allografting in these problems vary. Hovell states "grafts inserted for cases of first arch dysplasia have entirely resorbed with complete relapse to the preoperative skeletal pattern". Well-documented case histories followed up to adulthood are not available except for cases of Hovell, and his were disappointing.

Rowe prompted us to apply the principles set forth in his concept, which did not involve elongation or augmentation by grafting initially but took advantage of bone already present. The hope was that lengthening the affected ramus, stabilized by interocclusal splinting, and orthodontically controlling the postoperative course would stimulate normal maxillary growth on the affected side. Failing this, it was anticipated that maxillary osteotomy with bone grafting could be done to drop the maxilla to proper relation with the mandible.

This concept of surgical treatment of condylar agenesis when it is a part of the first arch syndrome is illustrated. Three cases are reviewed briefly. In two of these cases there is no semblance of coronoid and condyloid processes and no sigmoid notch, simply a rounded nub of bone in their place.

Our results in this group of patients treated according to Rowe's concept coincide with Hovell's observations - there has been a tendency toward regression (shrinkage in the mandible and less than normal growth in the maxilla). With 7 years of follow-up, some improvement has been observed but less than hoped for, and at this time we believe all of these patients will need maxillary as well as additional mandibular surgery as they reach maturity.

An article by Ware and Taylor published in 1966 reporting experimental transplantation of cartilaginous growth centers to replace condyles in monkeys was overlooked until after 1970 when the theory was given practical application in children. We have been encouraged by reports of benefits from transplantation of costochondral junction growth centers to replace defective mandibular condyles in children and have applied this concept in six young patients - one suffering from first arch syndrome and five whose conditions were caused by treatment for ankylosis. This procedure theoretically takes advantage of the growth spurt that occur in the immediate prepubertal years. Although no conclusions can be drawn from this limited experience, this transplantation process probably offers the best hope for young patients with condylar agenesis, regardless of etiology, that has come to our attention to date. Other reports are inconclusive, but in a recent communication, Ware stated that he has had to reoperate on two patients because of excessive growth from the grafted rib.

There is even more need for positive, definitive methods by which to correct progressive facial asymmetry caused by mandibular growth dysfunction since parental anxiety generated by this problem creates excessive psychological interaction between parent, child, and doctor. During the developmental years when there is minimal or no improvement by orthodontic, surgical, or combined orthodontic and surgical treatment, or no treatment at all, the child becomes increasingly more aware of the abnormality until in the pubertal and pospubertal period, he meets with constant peer assaults. In our opinion, early treatment of an obviously worsening condition aids the parents psychologically and is a confidence stimulator to the child - certain a better alternative than having the child endure the condition until full growth has been obtained.

Early surgical repositioning of the mandible is necessary in order to take advantage of the enormous growth spurt that occurs in the immediate prepubertal years. The psychological milieu present at that precise time results in many positive advantages. First, there is active growth in the autogenous bone and cartilage used for grafting. Second, the recipient site is in a stage of active bone formation. Third, all growth centers involving the surrounding normal bones are actively increasing in size. The maxillary alveolar processes bilaterally are being driven inferiorly and anteriorly by rapid growth at the maxillary suture lines. As a result, it is only at this precise period in growth that one may consider the use of a procedure that will result in the surgical repositioning of the mandible alone. The canted occlusion is corrected by repositioning the mandible and allowing for the subsequent unrestricted growth inferiorly and anteriorly of the maxillary alveolar process on the affected side.

The technique for costochondral grafting varies somewhat depending on the problem. The lines of osteotomy and placement of the rib as suggested by Ware are illustrated.

1. An incision is made over the surface of the sixth, seventh, or eighth rib from the lateral sternal border to the lateral portion of the chest wall. The rib is exposed from lateral sternal border tothe point of greatest curvature on the lateral side, depending on the amount of rib needed. The rib is removed with care taken to *include approximately 1 cm of costal cartilage* and to avoid pleural perforation. The rib is wrapped in a wet gauze sponge and placed on the back table.

2. A standard Risdon approach is made at the angle of the mandible on the affected side. The skin incision must be placed approximately 1 cm more inferiorly than usual in order to preclude closure immediately over the repositioned angle of the mandible.

3. The periosteum lateral to the vertical ramus of the mandible is elevated with a broad periosteal elevator. A Thompson ramus retractor is inserted into the sigmoid notch, but when no notch is present, any broad retractor will suffice.

4. An inverted L osteotomy is accomplished in the standard design with the horizontal cut superior to the mandibular foramen, joining the vertical cut just posterior to it and then extending inferiorly to the lower border of the mandible at the angle. Anomalous anatomy may dictate alteration in design of osteotomy. The osteotomy can be accomplished with rotary or oscillating cutting instruments.

5. A standard oblique osteotomy is usually necessary on the normal side. Both the wounds are packed and draped out of the field while the surgeons enter the mouth to immobilize the mandible in the preplanned postoperative position employing an interocclusal splint (wafer) and intermaxillary elastics. The spint is constructed in a manner that causes opening of the interocclusal distance on the affected side.

6. After the surgeons change gloves, the wound on the affected side is entered and a bony portion of rib is fitted into position in the newly created space in the inverted L osteotomy.

7. The remaining portion of the rib containing the cartilage is then cut to a length sufficient to fit from the glenoid fossa area along the posterior border of the mandible and is wired into position. That which is placed in the void created by the osteotomy is checked for proper position prior to closure.

8. If indicated, a short portion of rib may be wired into position at the inferior border of the mandible to effectively lengthen the vertical ramus and decrease the mandibular angle.

9. The wounds are closed and a semipressure dressing is applied.

The preceding technique is used where there has been no previous surgical intervention; however, if a prosthesis or other foreign substance has been placed in the condyle area previously, that substance is removed and replaced with the costochondral graft without osteotomy at all. If the mandible cannot be freely distrated inferiorly to accommodate the interocclusal splint (wafer), coronoidotomy may be helpful.

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When patients with condylar agenesis have been treated with unsatisfactory results or not treated at all during the developmental years, accepted conventional methods are the only recourse. Results of surgery for these patients after growth is completed are not satisfactory as a result of the associated shortage of investing soft tissue, which places a deinite limit on the amount of correction physically possible.

Apertognathia (Open Bite Deformity) and Other Occlusal and Jaw Abnormalities

Apertognathia, maxillary protrusion and retrusion, and other occlusion and jaw disharmonies and irregularities are correctable surgically or may be improved sufficiently to greatly facilitate subsequent orthodontic or dental restorative care. Selection of a proper operation for correction of a given problem must be based on a critical examination of the patient's appearance, study of models, and cephalometric analysis. The relationshipd of the upper lip to the upper incisor teeth in resting, speaking, and smiling positions, correlated with the relationship of segments of sectioned study models, provides the most preoperative information. Murphy and Walker emphasize the benefits of combined orthodontic-oral surgery workup, using photographs, study casts, and cephalometric roentgenograms. Depending on the results of these studies, surgery may be accomplished in the anterior maxilla, posterior maxilla, anterior mandible, mandibular rami, or a combination of more than one site.

A multiplicity of etiological factors exists in this category of deformities and occlusion irregularities. Principal among these causes are interference with the condylar growth center, abnormal tongue habits, and lip and finger sucking. *When the deformity is caused by habit, corrective surgery should not be undertaken until the habit has been overcome. This is especially the case in apertognathic conditions caused by tongue thrusting and reverse swallowing.*

A number of *basic* operations are available for use in correction of these deformities and occlusal disharmonies, and the surgical techniques will be described later in this section. These basic operations, which are now generally accepted and utilized, have evolved over the years since Hullihen's historical first operation was performed in 1849. Blair and many others since then have recommended the procedure or modification of V-shaped osteotomy for correction of open bite. Babcock, Limberg, and Pichler and Trauner suggested operations in the ascending rami of the mandible to allow for repositioning of the mandible anteriorly and closure of the open bite relation. The principle of vertical sliding osteotomy to lengthen the ramus was suggested in the first edition of this textbook.

When the open bite deformity is associated with prognathism, a different problem presents. Thoma suggested a trapezoid ostectomy in the body of the mandible, with the amount of bone excised determined by geometric measurement of the degree of open bite. Shira applied the principles of ramus vertical osteotomy in 8 cases of open bite and reported "gratifying results with little tendency for remission". We have also had good success with correction of open bite by vertical (not oblique) sliding osteotomy in the rami but have observed a greater tendency toward relapse than in ordinary prognathic cases. Since the overal vertical length of the ramus is definitely elongated or extended (by vertical sliding), it is our conviction that *decortication, direct transosseous wiring (overcorrected), and coronoidotomy are essential.* At the time of surgery, if anterior open bite cannot be reduced freely and without binding in the operative site, *it may be necessary to detach the sphenomandibular ligament from the lingula below the mandibular foramen.* This can also be done if the operation is being accomplished by intraoral sagittal splitting. *Direct transosseous wiring is virtually impossible if intraoral sagittal splitting or subcondylar (oblique) osteotomy is used in attempting elongation of the ramus.* Furthermore, *subcondylar (oblique) osteotomy is never indicated* as a method for correction of anterior open bite. Mohnac suggests "replacing the musculature at a higher point" when closing the soft tissue in these cases. *Also, one should plan for 6 to 8 weeks of immobilization. Most important of all, the abnormal tongue habits must be corrected preoperatively,* and the patient should continue under the care of a speech therapist for several months postoperatively. Many believe that the tongue will adjust further during the period of immobilization after surgery; however, *if there is any noticeable tendency to relapse, there should be no hesitancy to perform partial glossectomy at any time.* Surgical detachment of the anterior belly of the digastric muscle at its origin on the medial surface of the inferior border of the mandible near the midline may also help overcome a tendency to relapse. Limberg cut the ramus from the mandibular notch obliquely downward to a point near the lower aspect of the posterior border of the ramus above the angle where a short horizontal extension carried the incision to the posterior border. He did not mention any restraining effect that the attachment of the temporal muscle might have but did find it necessary to detach the stylomandibular ligament to permit downward movement of the body of the mandible. According to Pichler and Trauner, these difficulties were overcome by altering the bone incision. By sectioning the ramus from its anterior border above the foramen (below the coronoid process) horizontally back and then vertically downward, neither the temporalis muscle nor the stylomandibular ligament impeded movement of the sectioned part. Their vertical bone incision was posterior to the foramen, thus avoiding injury to the nerve.

V-shaped ostectomy in the body of the mandible

Technique. The principle and technique for V osteotomy are essentially the same as described of ostectomy in the body of the mandible for correction of prognathism. Unless edentulous spaces are present in appropriate locations, a tooth (usually a premolar) must be extracted bilaterally. Two sets of instruments should be set up, one for the intraoral work and the other for the extraoral. The operation is done as a single procedure, the intraoral being accomplished first.

1. The patient is prepared and draped in the customary manner with curtain drapes to separate the intraoral operation from the extraoral.

2. Generous mucopeiosteal flaps are elevated buccally and lingually, with care exercised to protect the mental nerve.

3. A long-shanked No 703 carbide fissure bur is used for all bone incisions in this operation.

4. The posterior vertical or transverse incision is made in the bone through the buccal and lingual cortical plates first, to a depth estimated to be just above the nerve.

5. The predetermined amount of bone to be removed is measured with calipers, and the anterior vertical bone incision is made, estimating the degree of angulation necessary to produce the desired V.

6. The intervening bone should be fairly free after the bur cuts are made and can then be removed with end-cutting rongeurs. Thus an effort is made to uncover and identify the inferior alveolar nerve or its mental and incisive branches or both. Although this part of the procedure is tedious and painstaking, it is worthwhile to attempt to save the continuity of the nerves.

7. Both sides should be done before the extraoral stage of the operation is begun.

8. The patient is then repositioned, and the operating team prepares for the submental extraoral procedure.

9. The soft tissue dissection does not differ materially from that already described except (a) the mandibular branch of the facial nerve is more superiorly related in this area and usually will not be encountered, (b) considerable vascularity is present deep to the platysma muscle, but none of these vessels has the caliber of the facial vessels, and (c) progress to the bone is therefore easier and more rapidly accomplished.

10. As soon as the periosteum is reached, it is elevated widely until communication with the intraoral operation is reached and the intraoral bone cuts are in view.

11. The V excision is completed to the lower border, using a No 703 bur. Once the anterior part of the mandible is mobilized, the segment of bone below the mental foramen can be freed and removed. Trauma to the nerve may result in temporary anesthesia, but even if severed, the nerve usually recovers. Excessive manipulation of the mobilized anterior part of the mandible should be avoided to prevent stretching or tearing of the nerve.

12. The bone ends are held firmly with larger Kocher forceps clamped to the lower border as the edges are planed to fit into close approximation. Planing is accomplished with a No 703 bur principally onthe proximal (posterior) fragment. Failure of approximation may occur at the lower border because of the sliding up and bending back of the distal (anterior) fragment.

13. The mouth is reentered and the occlusion established anteriorly. Intermaxillary fixation is secured. Although not feasible in every instance, satisfactory results have been obtained in using a cast lingual splint on the lower teeth in these cases. This splint is cast to fit a study model that has been sectioned and repositioned. When this stage of the operation is reached, the mandible is moved into position and the teeth in it are wired to the lingual splint or a precast metal labial splint. Orthodontic appliances offer a positive means of fixation also. In any case, firm immobility must be established by some means in the dental arch between the anterior and posterior fragments.

14. The bone ends are then wired together inferiorly and the extraoral wounds closed in anatomical layers as described previously.

15. Dressings and postoperative care are routine.

16. Healing time is dependent on the accuracy of bone approximation and adequacy of immobilization.

Sliding osteotomy to lengthen the rami (inverted L or vertical)

The osteotomy may be designed in different ways, depending on the problem. The inverted L-shaped osteotomy described by Pichler and Trauner may be indicated, especially in small rami, such as are seen in agenesis, or the straight vertical osteotomy (and coronoidotomy) from the mandibular notch may be chosen. However, when the rami are to be lengthened to correct the ordinary anterior open bite problem, the following operation is recommended.

Technique for sliding osteotomy to lengthen the rami

1. The approach to these operations is entirely extraoral and is the same as described previously.

2. If the inverted L or straight vertical osteotomies are selected because of smallness of the ramus, the cuts are outlined on the lateral surface with a No 702 carbide bur and completed with the smaller gauge No 701. The entire L or straight cut should be done with these two small burs because of thinness of the bone.

3. From template studies ("paper cuts") a predetermination is made of the amount of lengthening needed in the ramus to correct the open bite and, if prognathism exists also, the amount of setback that should be anticipated.

4. A *long* vertical cut should be planned to ensure plenty of length to the proximal fragment at a relatively low level on the distal part. This vertical osteotomy may be straight, curved, or angular and is started with a No 703 carbid fissure bur cut into the lateral cortex from mandibular notch to the angle.

5. Coronoidotomy is essential and accomplished in the routine way by No 14 drill perforations and fracture with chisel and mallet.

6. Decortication is also essential, since success of the operation depends in part on close approximation of the fragments and direct transosseous wiring. The first step in decortication is accomplished by making a second vertical cut in the cortex roughly parallel and anterior to the first. Note the anterior black line in the figure which was determined by the relation established when the distal (body) part was moved to a desirable occlusion relation. After both vertical cuts are completed through the lateral cortex, using caution over the approximate course of the mandibular canal, horizontal steps are cut at 6 to 8 mm intervals with a sharp No 703 carbide fissure bur held at an acute angle to the surface of the bone. Thus steps are placed without risk of penetrating too deeply. Horizontal steps can be made as far toward the sigmoid notch as necessary. Usually they need be extended only to the level of the foramen. Segments of cortical plate remaining between the horizontal steps are then excised using a sharp No 3 Stout chisel *with the bevel down.* Decortication

accomplished in this manner is accurate, fast, and carries little risk of injury to the contents of the mandibular canal.

7. Vertical osteotomy is completed only after decortication and coronoidotomy have been accomplished on both sides. The cut is completed through the medial cortex from the foramen to the lower border first and then on to the mandibular notch.

8. After the vertical osteotomy on both sides has been completed, the oral cavity is entered to be certain that occlusion can be freely established in the incisor relation without restriction or force.

9. If there is any problem in obtaining unrestrained anterior relation, the operative sites are reentered to look for the impediment. One of the following may be necessary: (a) freeing of temporal muscle attachments below the site of the coronoidotomy, (b) detachment of the sphenomandibular ligament from the lingula, or (c) excision of bony interference in the subsigmoid area above the mandibular foramen.

10. Once unimpeded occlusal relation in the anterior area is assured, the mandible is immobilized into the predetermined relation. Cast labial splints or orthodontic appliances are preferred to arch bars, since the perior of immobilization will be protracted (6 to 10 weeks), and most of the intermaxillary ties will be in the anterior part of the arches, where extrusion of teeth may complicate the postoperative course. Cast splints serve to protect the teeth as well as provide fixation anchorages. When splints are used, the patient should be instructed to use a Water Pik, since enamel may become hypoplastic if good hygiene is not provided.

11. When occlusion is secure, the operative sites are reentered, and the proximal fragment is adjusted to the decorticated area on the distal (body) part. Mortised inlaid result is desirable, with the tip of the proximal fragment neatly fitted into a notch in the cortex. Some fitting is always needed and readily achieved by using a bur appropriately and readily achieved by using a bur appropriately on the high spots, medial of the proximal fragment and lateral on the decorticated part of the distal fragment.

12. When fragments are finally well approximated (is is wise to allow for overcorrection), the parts are held in the desired relation, and a small drill hole is placed through both fragments. While the bone is held together, a doubled 0.016-inch stainless steel wire is threaded through. The double end is retrived and cut. One wire is then tied around the posterior border and one carried out through another hole anterior to the first. The proximal fragment is thus securely fixed on both sides.

When rami are lengthened as in this case, paresthesia of the lip almost invariably is a sequela because of stretching of the nerve between the foramen ovale at the base of the skull and the mandibular foramen.

The technique of osteotomy just described must never be modified to place the line of incision through the bone in an oblique direction from the mandibular notch to the posterior border of the ramus above the angle, but the line of incision must always be vertical or even anterior to the angle. Decortication is indicated, especially if prognathism coexists with apertognathia. *Direct wiring with overcorrection is always indicated.* Severing the coronoid process (coronoidotomy) to eliminate the pull of the temporal muscle helps to prevent relapse when a straight vertical cut from the mandibular notch has been made. These extra steps should be routine in correction of anterior apertognathia by this operation in the ramus.

The case illustrated is not ideal for application of this technique because of the reverse curve in the occlusion. In cases in which there is level occlusion and models can be related without rocking, the results obtained by this method are excellent and dependable.

Intraoral Segmental Osteotomies

Anterior mandibular segmental osteotomy

Hullihen's procedure for the correction of a mandibular deformity produced by burn scar contractures represents the first anterior mandibular segmental osteotomy. Illustrations of this procedure published in *Dental Cosmos*in 1849 depict an operation not unlike those used today to correct protrusion of the mandibular teeth resulting from dental rather than skeletal malformations. Hullihen completed the case by using a second procedure that excised the scar and placed a skin flap in the defect, thereby improving lip contour.

In 1942 Hofer used a similar approach to accomplish the forward movement of the anterior mandibular segment. In 1910 Dabcock described the extraoral operation to accomplish the forward movement of a mandibular segment. Köle reported the use of circummandibular wire in the midline to stabilize the osteotomized segment and a modified intraoral incision, which allowed for unimpedxed forward movement of the segment.

Technique for anterior mandibular osteotomy (Hofer)

1. A paragingival incision is made in the free mucosa 2 mm from its junction with the attached gingiva. The incision is initiated at the first molar position and carried forward to the area of planned osteotomy where it passes to the crest of the gingiva. It is then continued from the crest of the gingiva into the paragingival area to the opposite osteotomy site where it again proceeds to the crest of the gingiva. It is completed by an extension paragingivally to the first molar area on the opposite side.

2. A subperiosteal flap is generated, and the chin prominence is degloved from mental foramen to mental foramen.

3. A bony incision is made with a No 703 bur in the site of the planned osteotomy parallel to the long axis of the cuspid tooth. The incision is carried to a point 3 mm inferior to the apex of the cuspid tooth. A similar incision is made at the opposite osteotomy site. The inferior ends of these incisions are connected across the midline.

4. Teeth in the osteotomy sites are now extracted.

5. A lingual flap from the crest of the gingiva to include a distance of two teeth on each side of the osteotomy site is elevated.

6. A periosteal elevator is inserted to preserve the lingual periosteum while penetrations of the lingual cortical plate are made along the line of the planned osteotomy with a No 703 bur.

7. The horizontal bony incision is completed from anterior to posterior with an oscillating Stryker saw blade.

8. The vertical osteotomy incisions are now completed with a fine, long-beveled chisel.

9. The freed segment is moved into the preplanned position. All modifications necessary to fit the segment to its new position should be made in the mandible, not in the segment. Removal of bone from the segment increases the possibility for damage to the root surfaces or apices of teeth within the segment. All segments being repositioned should go into place without the exertion of pressure.

10. Three 26-gauge transosseous wires are placed along the horizontal osteotomy.

11. A horizontal mattress suture with No 3-0 Dexon suture material is placed across the gingival crest at each osteotomy site.

12. The surgical splints are wired into place.

13. The soft tissues are closed, using No 3-0 Dexon suture material in a continuous horizontal mattress format.

14. A pressure bandage of gauze covering the lip and held in place by a 2.4 cm strip of adhesive tape that completely encircles the mandible and neck is placed.

The anterior maxillary and mandibular segmental osteotomies provide the refinement of lip contour and anterior occlusion that orthodontic treatment would provide if it were available or indicated. There are two situations, however, in which surgical movement takes precedence over orthodontic movement. In one situation, an idiopathic resorption of tooth roots occurs after the application of minimal orthodontic forces. Evidence of root resorption appears radiographically after 1 month of attempted movement. Surgical repositioning will provide the solution to the problems inherent in these cases. Care must be taken to ensure that segments to be moved are completely free before the application of splints to exclude pressures during the stabilization period. In the second situation in which surgical rather than orthodontic treatment is required, there is an anterior open bite of sufficient severity to require the displacement of the teeth with the alveolar process. This type of case, when treated orthodontically, has a proclivity for relapse.

Anterior maxillary osteotomy

Surgery for the maxillary osteotomy may take one of three forms. An initial discussion of the possibilities for surgical intervention was presented by Cohn-Stock in 1921. The single-stage, predominantly labial approach was first reported by Wassmund in 1926. Axhausen added a tunneling procedure on the palate. Schichardt preferred a two-stage procedure, with the palatal side being treated first and completion of the surgery 4 to 6 weeks later from the labial approach. Wunderer modified Wassmund's original operation in 1962. His single-stage, palatally oriented procedure has many advantages that make it the procedure of choice for most conditions requiring anterior maxillary repositioning. The basic operations are versatile. The segment to be treated may include both premolar teeth bilaterally and all the anterior teeth or any of the various segments within these limits. Furthermore, surgical splitting in the midline permits two segments to be moved independently of each other. The closure of diastemas, recontouring of the anterior maxillary arch, repositioning of segments posteriorly, movement of segments superiorly or inferiorly, rotation of parts, and anterior movement with bone grafting are surgically possible.

Technique for anterior maxillary osteotomy - labial approach (Wassmund)

1. A paragingival incision is made from a point two tooth widths proximal to the area of the planned osteotomy in the buccal sulcus and carried anteriorly to the gingival crest in the area of osteotomy. This incision is continued paragingivally in the labial sulcus to the planned osteotomy site on the opposite site of the dental arch. Here again it is carried to the gingival crest and completed paragingivally two tooth widths proximal to the osteotomy site.

2. A mucoperiosteal flap is generated superiorly to expose the piriform aperture bilaterally and the anterior nasal spine anteriorly.

3. Teeth in the planned osteotomy sites are extracted.

4. Vertical bony cuts are made in the lateral maxillary cortical plate at the midpoint of the planned osteotomy site. These are carried superiorly to a point approximately 3 mm superior to the canine tooth apex. The anterior bony incisions are completed by continuing the cuts medially to a point on the most lateral dimension of the piriform aperture. These bony cuts are preferably made with a narrow, tapered fissure bur, No 700.

5. Attention is now directed toward the palatal portion of the procedure, where a subperiosteal tunnel is generated in the areas of the planned palatal osteotomy. This tunneling modification was proposed by Immenkamp.

6. While the palatal tissues are protected with a suitable retractor, the bony incision is carried from the crest of the alveolar bone in one osteotomy site across the palate to the crest of the alveolus on the opposite portion of the arch. Care must be taken to avoid penetration of the nasoendotracheal tube.

7. The remaining bony attachment of the anterior maxillary segment, the nasal septum, is severed with a narrow single-beveled osteotome along the floor of the nasal cavity.

8. The segment is freed manually by covering it with a gauze sponge, grasping it, and manipulating it until it is free of all attachments except the palatal pedicle.

9. Any bony portions within the osteotomy sites that resist the placing of the segment into its postoperative position are removed with a No 703 tapered fissure bur. Relapse is possible if the segment cannot be repositioned with a minimum of effort. A palatal stent with occlusal and incisal extensions constructed on the postoperative planning models is an excellent aid when employed during the contouring of ostectomy sites.

10. A horizontal mattress suture is placed to reposition labial and palatal tissues over the alveolar crest at each of the osteotomy sites. These sutures are placed at this time because they can be placed more easily and accurately prior to the placement of stabilizing splints.

11. Surgical splints are then fixed into position with circumdental wires.

12. The buccal and labial wounds are closed with a continuous horizontal mattress suture, using No 3-0 Dexon material.

Anterior maxillary segmental osteotomy (Wunderer)

Wunderer developed his procedure to provide a palatally oriented approach to the sectioning and repositioning of the anterior maxillary segment. Because the segment is pedicled on the labial mucoperiosteum, it is possible to rotate it anteriorly for better visualization of the recipient sites. Hence bony trimming may take place under excellent vision.

Technique for anterior maxillary segmental osteotomy (Wunderer)

1. A 2-cm vertical incision is made one tooth width posterior to the planned osteotomy sites bilaterally. A mucoperiosteal flap is generated to expose the osteotomy sites in the alveolar bone bilaterally. These flaps are extended subperiosteally beyond the extent of the original mucosal incision by tunneling superiorly and medially to the margin of the piriform aperture.

2. Incisions are made in the bony cortex in the area of the planned osteotomies with a fissure bur. These are carried superiorly to a point 3 mm above the adjacent tooth apex and then inclined medially to the piriform aperture.

3. Attention is not directed toward the palate where a paragingival incision is made. This is planned so that it may extend from the first molar teeth anteriorly around the arch with extensions to the gingival crest in the areas of the planned osteotomies.

4. Bony incisions are made in the planned areas across the palate with a fissure bur. If a midline section is contemplated, an osteotomy incision is also extended from the mid palatal point of the first palatal incision to a point 3 mm from the crest of the interradicular bone between the two central incisor teeth.

5. The midline should be fractured with a fine, long-beveled osteotome at this time.

6. The lateral osteotomy incisions are now developed from the labial to the palatal sides with a fine osteotome.

7. The segment is freed completely by covering it with gauze sponge and, with controlled manual force, fracturing it free of its remaining attachments.

8. The recipient sites are contoured with a bur.

9. The mucoperiosteal flap is replaced across the alveolar crest with a horizontal mattress suture.

10. Stabilization splints are fixed into position.

11. Soft tissues are closed with a continuous horizontal mattress suture.

12. A stent or gauze pack is placed over palatal tissues to prevent the formation of a hematoma on the palate.

Posterior maxillary osteotomy

Technique. Posterior maxillary osteotomy may be used to expand or narrow the maxillary arch unilaterally or bilaterally and to close vertical dimension posteriorly to correct anterior open bite. It is accomplished iun a two-stage operation, the palatal side being completed first.

1. Gingival incisions are made into the interdental papilla from the second molar forward to the central incisor on the palate.

2. Palatal mucoperiosteal tissues are elevated from the gingival margin, exposing the greater palatine foramen and contents. It is unnecessary to strip back the entire palatal covering.

3. Using a No 703 carbide fissure bur, a cut is made anteriorly from the foramen to the first premolar area, where it is angled downward to the alveolar ridge between the premolar and canine teeth. This cut is kept in a vertical plane parallel with the long axis of the teeth and is carried through the palatine process of the maxilla to the maxillary antrum. The cut is then carefully extended posterolaterally to the pterygomaxillary fissure.

4. The palatal flap is replaced and sutured, and the second stage is delayed 3 to 4 weeks to ensure reestablishment of the blood supply.

5. After the delay a large buccal flap is raised from the gingival margin, exposing the lateral aspect of the maxilla from the canine prominence posteriorly to the tuberosity.

6. A thin, vertical cut is made between the canine and first premolar using a No 701 or 702 carbide bur. (Occasionally the first premolar must be removed to permit desired placement of the sectioned part.)

7. A horizontal cut is made with a No 703 bur from the pterygomaxillary fissure anteriorly under the zygomatic process above the apices of the teeth into the maxillary antrum and anteriorly, joining the vertical cut at the canine fossa.

8. If the sectioned part is to be depressed and impacted upward into the sinus, it may be necessary to remove additional bone along the horizontal bone cut.

9. A broad, flat, thin osteotome is usually needed to complete the surgical fracture.

10. A prefabricated labial cast splint is utilized here also to ensure union and resist relapse. Intermaxillary fixation with 0.016 gauge stainless steel wire is applied lightly but only between the anterior teeth.

Horizontal maxillary osteotomy (Le Forte I procedure)

Early efforts to reposition the entire maxillary alveolar process were directed at correcting traumatically malpositioned maxillary complexes. The dangers of maxillary sinus infections and fistulae as well as the possibility of necrosis of bony segments deterred many surgeons from attempting this correction. Axhausen in 1934 reported the first horizontal maxillary osteotomy. Wassmund followed with a method of advancement that employed a combined surgical-orthodontic movement. The sectioning of the lateral maxillary wall, the

lateral nasal wall, and nasal septum was accomplished by a single horizontal incision from the tuberosity across the midline to the opposite tuberosity. Two weeks later elastics were placed on previously attached arch appliances. These were used to draw the partially freed maxillary alveolar process into the desired position. Köle developed a two-stage total maxillary osteotomy. In the first stage he exposed the entire bony palate. An osteotomy in a block U form was made from the posterior border of the palatal bone through the greater palatine forammen, anterior to the second premolar tooth area, then across the palate in the frontal plane to join a similar osteotomy on the opposite side. In the second stage, cuts from the piriform aperture to the pterygomaxillary fissure and along the floor of the nose to detach the nasal septum were made. Recently Paul reported a similar procedure in a single-stage operation. Mohnac used a similar procedure to reposition a malunited maxillary fracture. He modified the palatal osteotomies by continuing them past the second premolar tooth to meet in the midline at the incisive canal. Bell and others have recently made numerous important contributions to the refinement of maxillary surgical procedures. The "down fracturing" modification of the Le Forte I osteotomy, with its subsequent exposure of the entire superior surface of the distal maxillary fragment, has opened a wide vista of innovations to the surgeon. The distal portion of the maxilla may be surgically segmented into numerous combinations from a superior approach. Good visibility and a substantial palatal pedicle are the two most obvious advantages of this approach.

Technique for horizontal maxillary osteotomy (Le Forte I)

1. An incision is made 2 mm superior to the junction of the free and attached gingiva from the zygomatic process of the maxilla across the midline to the zygomatic process on the opposite side.

2. A mucoperiosteal flap is generated superiorly to the infraorbital foramen, exposing the zygomatic process of the maxilla and the piriform aperture.

3. A bony incision with a No 703 tapered fissure bur is made from the base of the zygomatic process of the maxilla anteriorly to a point approximately 1 cm above the floor of the nasal cavity. A similar osteotomy cut is made on the opposite side.

4. The periosteum from the base of the zygomatic process to the pterygomaxillary fissure is elevated by a tunneling procedure.

5. The pterygoid plates are fractured from the posterior portion of the maxilla with a curved Obwegeser osteotome.

6. The nasal septal cartilage and vomer attachments are severed from the maxilla with a fine osteotome. Care should be taken to protect the nasopharyngeal area with a finger because perforation of the nasoendotracheal tube is possible.

7. The lateral wall of the nasal cavity is sectioned at a level below the attachment of the inferior turbinate bone with a fine osteotome.

8. The maxilla may be freed of its remaining attachments by one of four methods. We prefer the use of Rowe forceps. The maxilla may also be fully mobilized by inserting both curved osteotomies or the Tessier instrument posterior to the maxillary tuberosities and rocking it free. In some instances the maxilla may be fully freed by placing a gauze sponge

over the teeth and manipulating the segment in all directions with hand pressure. It is of utmost importance that the freed maxilla go to the new position with minimal force.

9. The teeth are not placed in the postoperative position and intermaxillary elastics used to maintain this occlusion.

10. Rectangular sections of autogenous crest of ilium are cut to a size that is equal to the amount of forward movement of the maxilla on each side, and these sections are inserted between the tuberosity and the pterygoid plates.

11. Transosseous wires are placed across the osteotomy sites in the lateral maxillary walls. These are tagged with hemostats.

12. The lateral osteotomy sites are grafted and the previously placed transosseous wires twisted to fix the maxillary fragments and bone grafts in position. These grafts are triangular in cross section.

13. The incisions are closed with No 3-0 Dexon suture material in a continuous horizontal mattress format.

Indications for horizontal maxillary osteotomy without a deficiency in the infraorbital rims. Retrusion of the maxilla associated with a normal configuration of the mandible is treated best by the repositioning of the entire maxillary alveolar process. In this manner, two of Obwegeser's three basic principles are satisfied. The basilar bone is placed in its proper position, and the dental occlusion is improved. When preoperative or postoperative orthodontic treatment is employed, the third basic principle, which is adjustment of the inclincation of the anterior teeth to the basilar bone, is satisfied.

Apertognathia as a result of a malposition or developmental deformity of the maxilla and not associated with a short superior lip may also be corrected by the repositioning of the full maxillary alveolar process. In cases associated with an abnormally short superior lip, the anterior open bite is best treated by repositioning the posterior maxillary segments in a cephalad direction, utilizing the Schuchardt technique.

Residual defects after cleft palate surgery are often also treated by repositioning the remaining maxillary alveolar process. In most cases the residual palatal and alveolar defects are bone grafted as a secondary procedure after the anterior positioning of the alveolar segments. The technique for bone grafting in the palate is technically difficult. Extreme case must be exercised to ensure that a watertight nasal mucosal seal is developed and that both the nasal and palatal flaps are tightly applied to the bone graft material. Thus the possibility of the development of a hematoma between flap and bone is eliminated.

Complications after horizontal osteotomy. Two complications are frequently associated with the horizontal maxillary osteotomy. Relapse is often reported. Trauner reports that the possibility of relapse is eliminated when sufficient overbite exists inthe maxillary anterior teeth to form a locked-in anaterior occlusion postoperatively. Another deterrent to relapse is the proper measurement and placement of the bone graft material between the maxillary tuberosity and the pterygoid plates bilaterally. Obwegeser recommends that the most anterior transosseous wires across the horizontal osteotomy sites bilaterally be placed so as to resist the tendency toward relapse of the osteotomized segment.

A frequent and troublesome complication after the maxillary procedure is secondary hemorrhage. The critical period appears to be between 7 and 10 days after the operation. Furthermore, the site of hemorrhage is most often the lateral nasal mucosa. Surgeons reporting fewer hemorrhages in this area section the lateral nasal wall with an osteotome introduced across the maxillary antrumm through the osteotomy in the lateral maxillary wall.

Small segment osteotomies

The technique for mobilizing small alveolar segments was developed in an effort to minimize the time required for orthodontic movement. A refinement of the earlier corticotomy technique developed by Bichlmayr and Köle was developed to pedicle the segments on either a labial or palatal flap rather than on the small segment of medullary bone contained within the osteotomy cuts. Bell showed with animal studies that the older corticotomy technique does not provide a sufficient blood supply to the segments. Both one-stage and two-stage approaches have been advocated. Kruger prefers a one-stage technique from a palatal approach. We prefer the two-stage approach.

Technique for small segment osteotomies

1. A full palatal flap is elevated.

2. Bony incisions with a No 700 bur to bleeding bone are made parallel to the long axis of the toors of the teeth to be moved. The incisions are joined across the palate.

3. The flap is repositioned.

4. Four weeks later a full labial flap is elevated.

5. Bony incisions with a No 700 bur corresponding to those on the palatal surface are made, taking care to limit the bur cut to 2 to 3 mm from the crest of the interradicular bone.

6. The individual segments are fractured free of their bony attachments with an osteotome.

7. The segments are placed into the preplanned position and fixed to an arch-stabilizing appliance.

8. The flap is replaced and sutured.

Techniques for moving small segments of alveolar bone with teeth have enjoyed recent widespread application. As with all new procedures, attempts have been made to broaden the scope of application beyond the inherent limits of the anatomical structures involved. Rapid orthodontics is a myth. The same limitations that apply to larger segments affect small segments. Equally true is the fact that orthodontic forces applied to small segments will cause the same deleterious effects to tooth structure if physiological norms are exceeded. Teeth moved in a small segment require careful follow-up and varying periods of postoperative stabilization with a retainer. We have found the moving of small segments of the mandibular dental arch unfeasible and unrewarding.

Complications (Intraoral Operations)

A discussion of the complications resulting from surgical procedures performed intraorally must be prefaced by an understanding of the true meaning of the terms *complication* and *sequela.* Even medical dictionaries are not entirely lucid on this difference. In our opinion, a complication is an unexpected condition occurring after and associated with an operation. Sequelae on the other hand are conditions that are commonly expected, occurring after and associated with operations. For instance, infection is a complication, whereas swelling is a sequela of soft tissue surgery. However, sequelae, when they are severe or not controlled with accepted postoperative care and handling methods, may cause complications. Thus the severity of swelling after the accomplishment of the same procedure may vary according to the length of time used to complete the case, the care with which tissues are handled, and the medical and mechanical means used to control postoperative edema.

First and foremost among preoperative measures necessary to eliminate or minimize complications is the history. A complete discussion of the art of history taking is not apropos here because it is presented extremely well in other chapters. The patient must be physically and psychologically able to cope with the surgical insult.

In our opinion, the preoperative administration of appropriate antibiotics and the steroid dexamethasone (Decadron) is de rigeur in all intraoral procedures involving tissues contiguous with the airway. An appropriate antibiotic should be administered preoperatively to all patients on whom major intraoral procedures are to be performed. The steroid and antibiotic may be given intravenously while the patient is on the table prior to the initiation of surgery.

The oral cavity must be cleansed preoperatively. Terry recommends tooth-brushing in the operating roomm as part of the preoperative preparation procedure. All sources of unusual intraoral contamination should be eliminated in the preoperative workup. Cleansing the mouth with aqueous thimersol (Merthiolate) or povidone-iodine (Bethadine) solution should follow the insertion of the throat pack.

Incisions must be positioned so that they afford the surgeon access to and a visualization of the entire operative site. Intraoral incisions are best made in the paragingival position rather than at the gingival crest. Incisions thus placed may be closed easier and with more assurance of a watertight seal. We prefer closing with a polyglycolic acid suture material (Dexon) in a continuous horizontal mattress suture format.

Extreme care must be exercised to restrict the operative field to the periosteal confines. Reports of profuse hemorrhage in most cases occur after the planned or inadvertent perforation of the periosteal covering in regions where there are large vessels contiguous to the operative field. Three areas requiring special care surround the vertical ramus of the mandible. These are the posterior border (retromandibular vein), the premasseteric incisure (facial vessels), and the lingual area (inferior alveolar vessels). Neuropathies also may be associated with perforation of the periosteum. Seventh nerve palsies have been reported. They are most likely caused by perforation of the periosteum at the posterior border of the vertical ramus of the mandible or at the lower border.

We are aware of three cases of profuse hemorrhage associated with large vascular anomalies contiguous to deformed mandibles. All were unilateral deformities. None showed

any roentgenographic evidence of bony involvement with the lesion. It would seem prudent then to order vascular studies of the external carotid vessel on the side of the contemplated surgery in this type of case.

Preoperative planning and care during surgery must be directed toward the maintenance of a wide vascular pedicle to all segments of bone being treated by osteotomy or ostectomy. Inadvertent stress on the soft tissues or the segment during surgery must be eliminated.

Osteotomy or ostectomy bony incisions must be made in areas as widely separated from tooth roots and apices as surgically possible. It is a wise maxim to make all alterations necessary to reposition maxillary and mandibular segments in the recipient site rather than in the segment itself. Teeth whose apices are inadvertently exposed during surgery should be endodontically treated before the operation is completed.

Obwegeser stresses that segments or portions of the maxilla or mandible being moved to new positions should go to position with the least force possible. Thus the entire maxilla freed by the Le Forte I procedure or the entire mandible freed by the sagittal osteotomy may be transported to position with a light tissue forceps. Furthermore, no undue stress should be exerted to place the segments within the confines of the surgical splints. Orthodontic band splints allow for the final, fine adjustment of position of segments without placing damaging stresses on the structures involved. Thus the segments may be placed in positions "besser als Modelen" (better than the models).

Intraoral drainage is recommended after the sagitall osteotomy of the mandible to minimize the large amount of edema associated with this procedure. A No 10 French catheter is perforated randomly for approximately 8 cm from the end to be introduced into the wound. This is placed with a stab incision anterior to the operative incision so that the tip is at the sigmoid notch. This is attached for 24 hours to low (40 psi), intermittent suction. No pressure dressings are required when this is done. Incisions are closed as stated previously with a biodegradable suture material.

Reports of complicagtions after the sagittal osteotomy of the mandible have been published by Guernsey and DeChamplain and by Behrman. The numbers and severity of complications associated with this procedure indicate that the surgeon must bring more than usual skill and a cursory knowledge of the procedure to the operating room. The technical difficulty dictates that he or she must have observed the execution of the procedure by a surgeon with some successful completions, that is, completions free of severe complications. Furthermore, the precision of the required osteotomy incisions and the limited access because of anatomical confines demand the use of specuially constructed instruments. In sumary, the sagittal osteotomy of the vertical ramus of the mandible, a worthwhile, useful operation, requires extraordinary preparation.

Conclusion

Robinson states that a "standardized outline of surgical technic for prognathismm is necessary in teaching residents". We hope this chapter may provide the basis for such an outline in surgical technique. However, training must never become a stereotyped process, otherwise variations from normal may not be coped with adequately when encountered. Students (residents) must be stimulated to think independently and individually and preceptors must teach *all* acceptable methods of corrective jaw surgery, including the more difficult

procedures and also those less frequently needed. Imagination and the versatility of many of the operations described herein make possible the correction of almost any conceivable deformity that may be present, but the results will depend largerly on how well the operation is planned and on the surgical ability of the surgeon. Blair's classic remark in 1907 that the mandible "is a hoop of bone capable of almost any kind of adjustment" is more realistic in this modern day than ever before. Astute and aggressive as he was, Hullihen would look on the many new innovagtions in maxillary and mandibular surgery and say, "Well done, but what are your new horizons?"