Blair was not concerned about the effects of severing the Mandibular Neurovascular bundle. Any effects he noted were nearly all temporary. Blair's fixation for the osteotomy was a combination of soft cement between the teeth and the use of intermaxillary wiring. He specifically did not recommend interosseous fixation at the site of surgery due to a fear of introducing infection. In 1909 (Blair 1909) he was performing his ramus sections above the level of the lingula Subsequently Blair specifically recommended against the sectioning of the ramus above the lingula due to lack of space and the likelihood of damaging major structures such as the parotid gland, large vessels and the Facial nerve. Blair's guideline for the incision was the occlusal table, and the cut had to be at or below the level of the lingula. On the lingula was considered to be the optimum site. (Blair & Ivy 1923).

Blair's procedure was via an external approach just anterior to the ear lobe, with the first incision approximately two centimetres long over the posterior border of the mandible. By drawing forward the skin, the parotid sheath was then exposed and opened at the anterior border of the gland. The gland was then retracted until the posterior border of the mandible could be palpated. An aneurysm needle was then passed between the gland and the posterior border and passed forward medial to the ramus between the ramus and the medial pterygoid muscle. The aneurysm needle was then exited through the cheek without perforating the oral mucosa. A Gigli saw was then pulled through and the ramus sectioned. Haemorrhage was then controlled by packing the surgical wound with either a sterile tape or a mildly antiseptic tape. The pack was removed at the third day. Precautions were taken to protect the various structures during sawing. (Blair 1915). A second operation

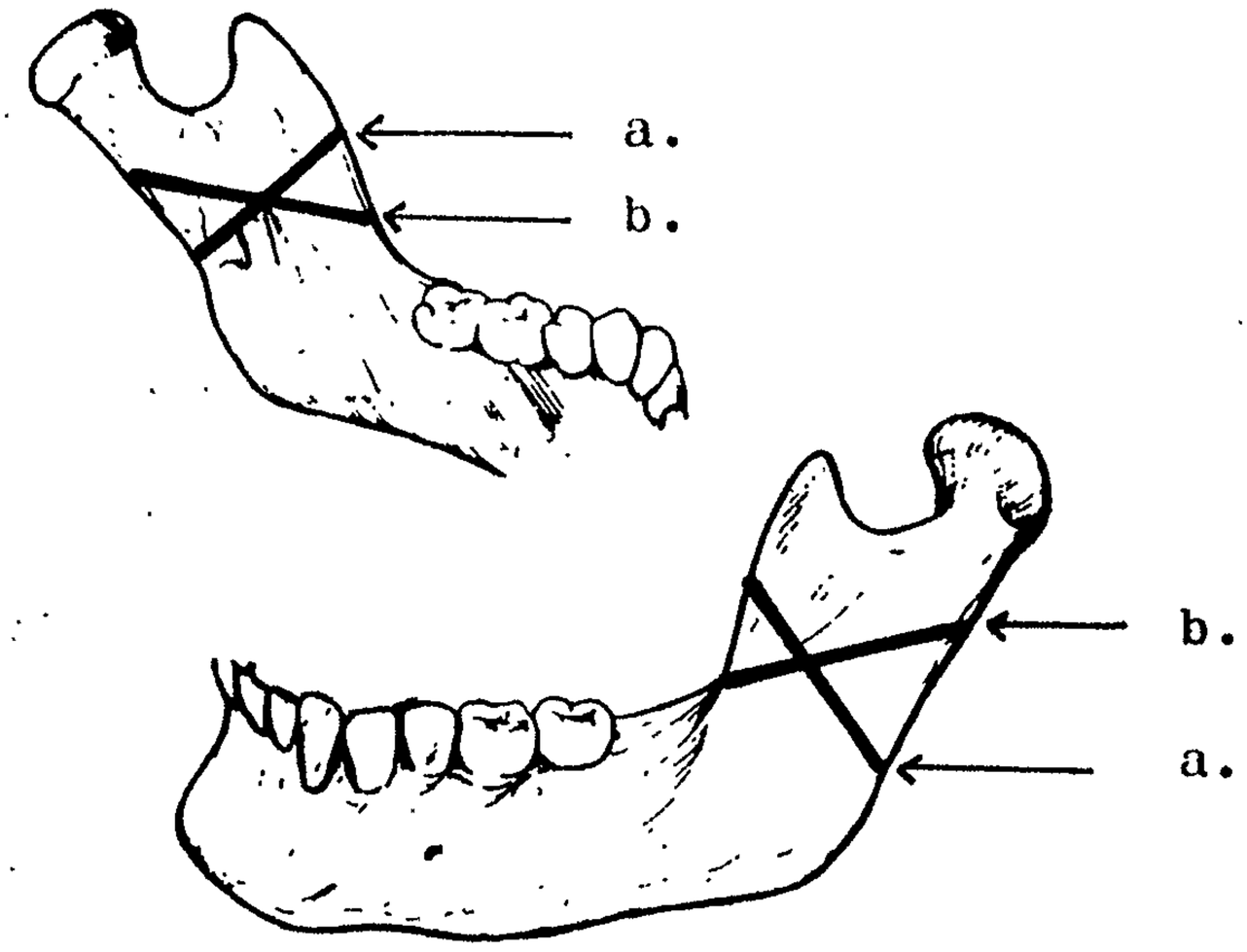
for retrusion was performed in 1908, which made use of a rib cartilage graft to the symphysis region to bolster the contour of the deficient chin. Otherwise the surgery was the same as described above.

Blair (Blair 1909) in a review of the state of the art at that time, put forward suggestions for future use and included some examples of his own.

By 1923 Blair (Blair & Ivy 1923) was recommending that if possible the section should be slightly oblique. The cut should be approximately five millimetres inferior on the anterior border than on the posterior border. That is the section should slope forwards and downwards. However Blair did concede that this degree of accuracy would be difficult to obtain in practice. A posterior gag was recommended to stretch the masticatory muscles and help reduce the chance of any post-operative open bite developing. Even with these precautions, selective grinding or even extraction of molar teeth was recommended on specific occasions, post-operatively. (Blair & Ivy 1923).

This procedure was endorsed by Dingman (Dingman 1944a, 1944b) who suggested that the angle of the cut be varied to produce a simultaneous opening or closing of the bite depth in addition to the correction of the protrusion or retrusion. See **diagram 63.**

Blair's procedure was also recommended for the correction of jaw asymmetry where the asymmetry was present in combination with mandibular retrusion. Where the correction of the



Dingman's Variations of the Oblique Horizontal Body Osteotomy for the Correction of:
a. Open Bite Deformity with Mandibular Retrognathism.
b. Closed Bite Deformity with Mandibular Retrognathism.
(1944).

Diagram 63

retrusion produced a reasonable occlusion but an unsatisfactory facial appearance in the chin region which was still not prominent enough, then Blair recommended the use of a cartilage or rib graft placed on the chin via an external approach. **See diagram 64.** (Blair 1921.)

Many of the procedures described for the correction of protrusion apply to the correction of retrusion. However most are better suited to the correction of protrusion and were developed for this purpose. In general the ramus procedures are more flexible for the correction of either protrusion or retrusion and even asymmetries or open-bites. This is because many of them do not require a graft

Receding appearance of chin due to loss of fatty tissue by operation.

Restoration of prominence of chin by costal cartilage transplant.

Blair's Genioplasty Following Ramus Osteotomy. 1923.

Diagram 64

to replace the amount of advancement. This applies more so where the degree of retrusion is mild to moderate.

During the 1940's there were many articles produced that weighed the advantages and disadvantages of ramus versus body procedures for the correction of mandibular deformities. Dingman (Dingman 1948) while a proponent of body procedures did try to put

both sides of the controversy in his 1948 paper. Despite an admitted bias he listed among the advantages of osteotomy of the ramus the following:

1. Affords the greatest possibility of avoiding the mandibular neuro-vascular bundle.
2. It is easier to execute.
3. It avoids the extraction of teeth and the sacrifice of useful bony structure.
4. It avoids the possibility of oral contamination.
5. It avoids or minimises the effects of muscle traction producing unfavourable displacement. (Dingman felt that this claim was erroneous.)

As an opponent he listed a larger number of disadvantages. These were:

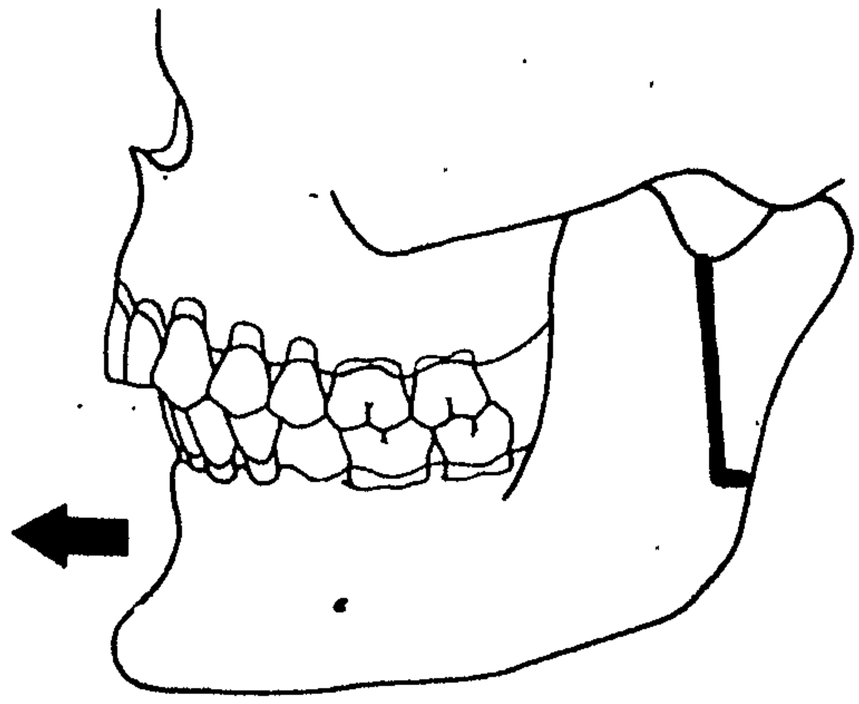
1. Parotid fistula.
2. Injury to the Facial nerve.
3. Serious haemorrhage from the Internal Maxillary artery.
4. Derangement of the muscles of mastication.
5. Overriding of the fragments.
6. Non-union or malunion (equally applicable to both procedures.)
7. Open bite deformities with post-operative relapse.
8. Longer periods of intermaxillary fixation.

9. There is no possibility of correcting any malrelation between the anterior and posterior teeth in the mandibular arch.

Smith and Johnson (Smith & Johnson 1940) were quite enthusiastic in their advocacy of ramus procedures. They listed the following advantages of ramus procedures:

1. The mandibular neurovascular bundle is preserved if the procedure is properly done.
2. No teeth are lost.
3. There is no post-operative haemorrhage or anaesthesia.
4. There is no anterior-posterior shortening of the arch.
5. There is no post-operative infection due to oral contamination or the insertion of wires.
6. Drains are not necessary.
7. There is only a small scar.
8. Orthodontists can produce a better result as no teeth are removed.
9. Only two, and not four as in the body procedures, intermaxillary wires are needed to produce fixation.

Slowly procedure preferences began to change.

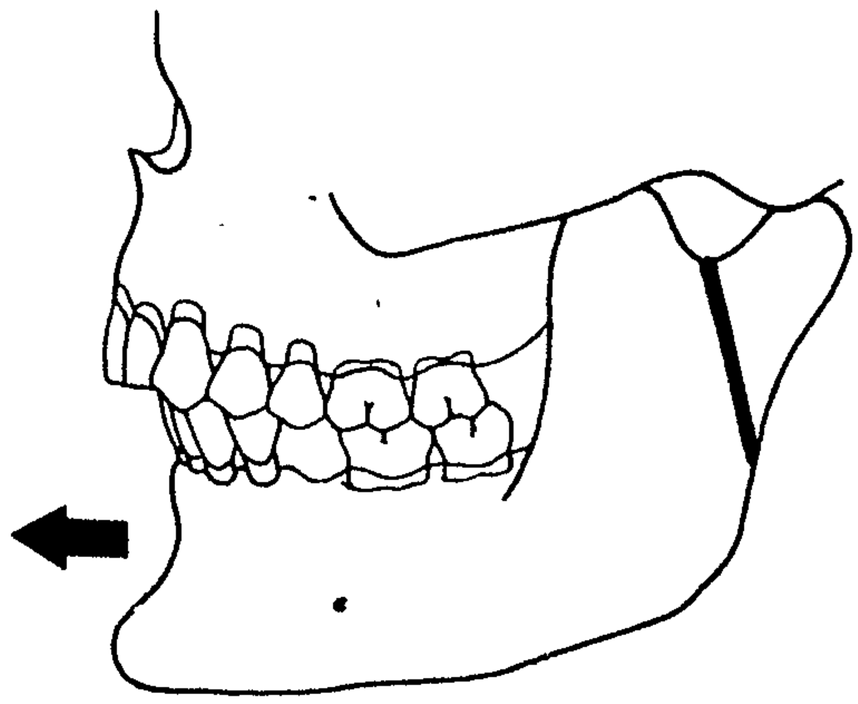


Limberg's Subcondylar Osteotomy. 1925.

Diagram 65

At the time of these arguments the proponents and opponents of the ramus and body procedures were approximately equal. The above comparison does serve to demonstrate the enthusiasm that each side of the argument brought to bear to put forward their own viewpoint. From the 1950's onwards, body procedures began to decline in popularity as ramus procedures began to assume dominance when surgeons such as Hovell (Hovell 1956) recommended that retrognathism was best corrected by ramus procedures with or without the use of chin grafts. This trend was helped still further by procedures such as the vertical ramus osteotomies and the sagittal osteotomies that were developed. The development of these procedures began with Limberg's subsigmoid osteotomy.

The subsigmoid type procedure that Limberg reported in 1925 (Limberg 1925) for the correction of open bite and microgenia type of deformities, see **diagram 65,** was the forerunner of the vertical osteotomies of the ramus that Caldwell and Letterman (Caldwell & Letterman 1954) developed. Limberg's procedure was performed via an external pre-auricular incision. Limberg (Limberg

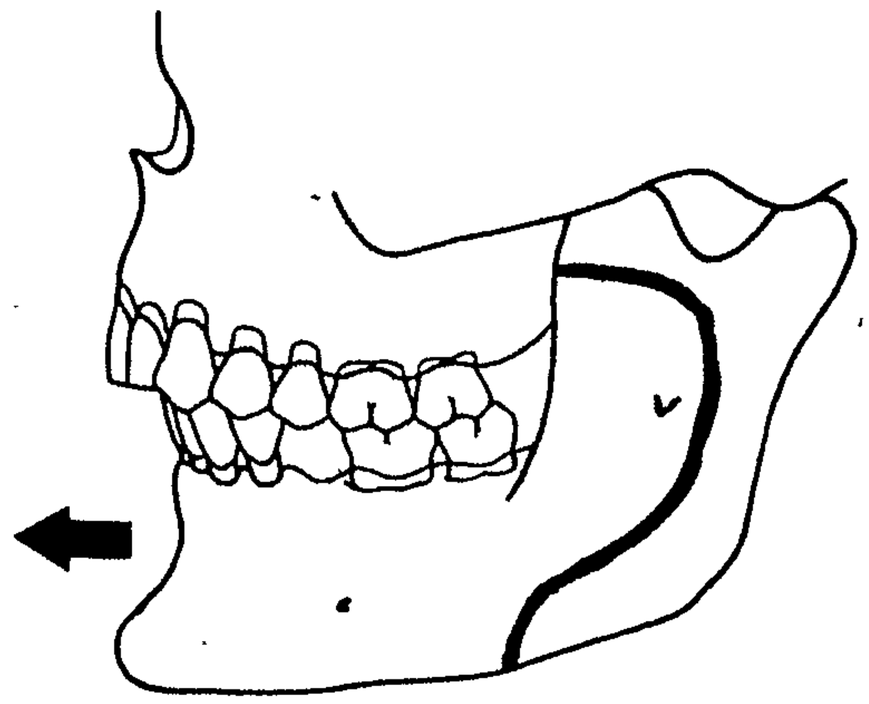


Kostecka's Subcondylar Osteotomy. 1931.

Diagram 66

1926) later recommended the use of a costal graft to advance the mandible even further forward. Kostecka later (Kostecka 1931) reported a very similar procedure to Limberg. The difference was that the final step of Limberg's was discarded and straight line section made instead. See **diagram 66.** Kostecka also used a blind external approach previously described by Blair (Blair 1915). Like Limberg, Kostecka used his procedure for the correction of open bite deformity. It was the Kostecka procedure that Hofer adapted (Hofer 1936, 1942) for the correction of mandibular retrusion using the Blair/Kostecka approach. However the procedure as reported by Hofer, was best suited to cases of mild to moderate retrusion.

In the attempt to find more satisfactory ways of achieving greater degrees of lengthening and correction of retrusion, two different styles of technique were being explored at the same time. Firstly, more unusual techniques such as the retrocondylar technique were propounded, and secondly, more extensive use of grafting either to the established procedures or to newer procedures was being recommended.



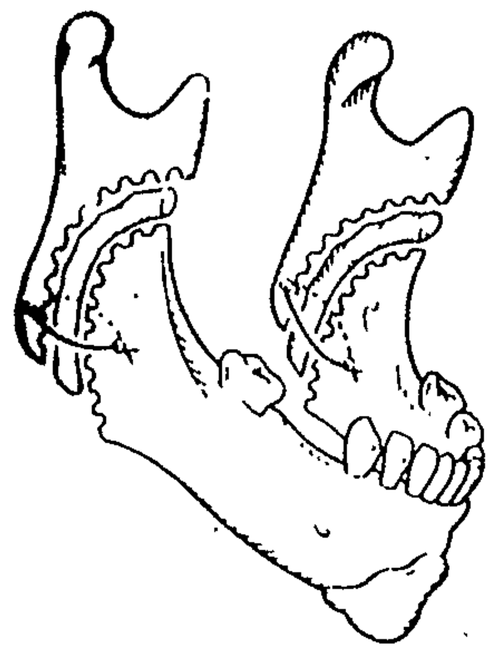
Wassmund's "S" Ramus Osteotomy, After Wassmund 1927.

Diagram 67

One of these procedures was the retrocondylar implantation procedure devised by Babcock (Babcock 1937) and later by Obwegeser and Trauner (Obwegeser & Trauner 1955). However, with this procedure, as the authors pointed out, the degree of correction that could be attained was not much, and the procedure was only only suited for the correction of mild retrusion. (See Condyle Procedures). Trauner and Obwegeser also recommended the use of genioplasty either as a simple addition of preformed acrylic using an external approach, or the more effective sliding body genioplasty for more severe retrusion of the chin. (See Body Procedures).

Development of the "Alphabet" Ramus Procedures.

Of the strictly ramus procedures, Wassmund (Wassmund 1955) reported what must be considered one of the forerunners of the "Inverted L" osteotomies designed to increase the degree of retrusion able to be corrected up to moderate retrognathism (as well as prognathism). The procedure was first reported in 1927 (Wassmund 1927) but was largely ignored initially. See **diagram 67.**

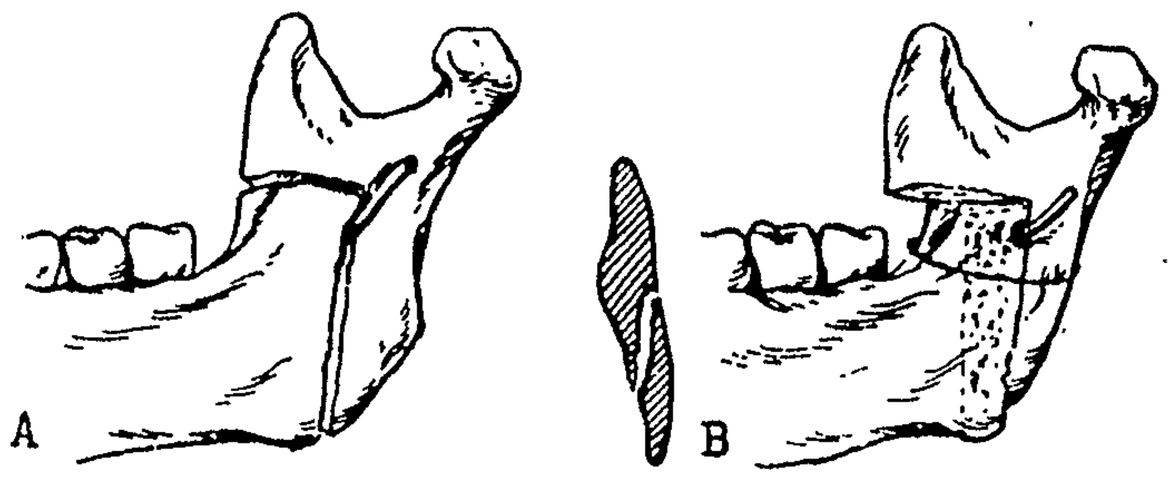


Immenkamp's Ramus Osteotomy
with Interposed Grafts.
After Immenkamp 1957.

Diagram 68

The bony section commenced as a vertical section that was posterior to the lingula and continued inferiorly to the angle/lower border. Where the procedure was for the correction of retrognathism, then Wassmund took the vertical section anteriorly in a further curve before taking the section to the lower border, in order to increase bony contact when protruding the mandible after sectioning. The superior part of the sectioning proceeded as a curve superiorly and over the lingula extending through the base of the coronoid process to finish on the anterior border of the ramus almost a horizontal section. The completed bony cut looked like an "S". If the procedure was for the correction of prognathism, then the last two curves were left out and the section finished vertically against the lower border.

Immenkamp (Immenkamp 1957) described a similar procedure for the correction of retrusion and pronounced the procedure satisfactory. See **diagram 68.**

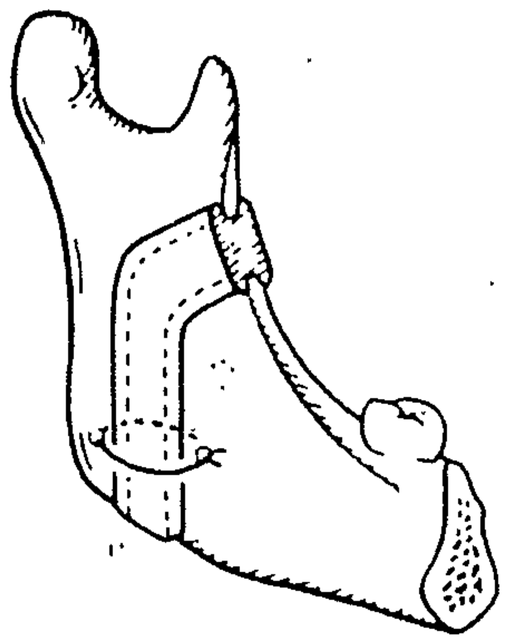


Trauner & Obwegeser's Inverted L Ramus Osteotomy,
After Trauner & Obwegeser 1955.

Diagram 69

Trauner and Obwegeser (Trauner & Obwegeser 1955) described a cut called the "Inverted L" osteotomy for the correction of protrusion. See **diagram 69.** However the approach was different. The first stage of the approach was an intra-oral horizontal cut from the anterior border starting from where Wassmund commenced his section cut, and continued in a horizontal line for approximately eighteen millimetres. A vertical section was then made to join up with the horizontal section through an extra-oral, submandibular (Risdon) approach. The second cut was posterior to the lingula.

The procedure was adapted by Trauner and Obwegeser for the correction of retrusion, and later by Schuchardt (Schuchardt 1961) for the same purpose. See **diagram 70.** The variation required the use of a graft, usually iliac crest although split rib was acceptable, to supplement for the missing bone. A further graft could be added to the chin if it was so desired. Both Trauner, Obwegeser and Schuchardt used iliac crest grafts and recommended this procedure for the correction of severe retrusion.



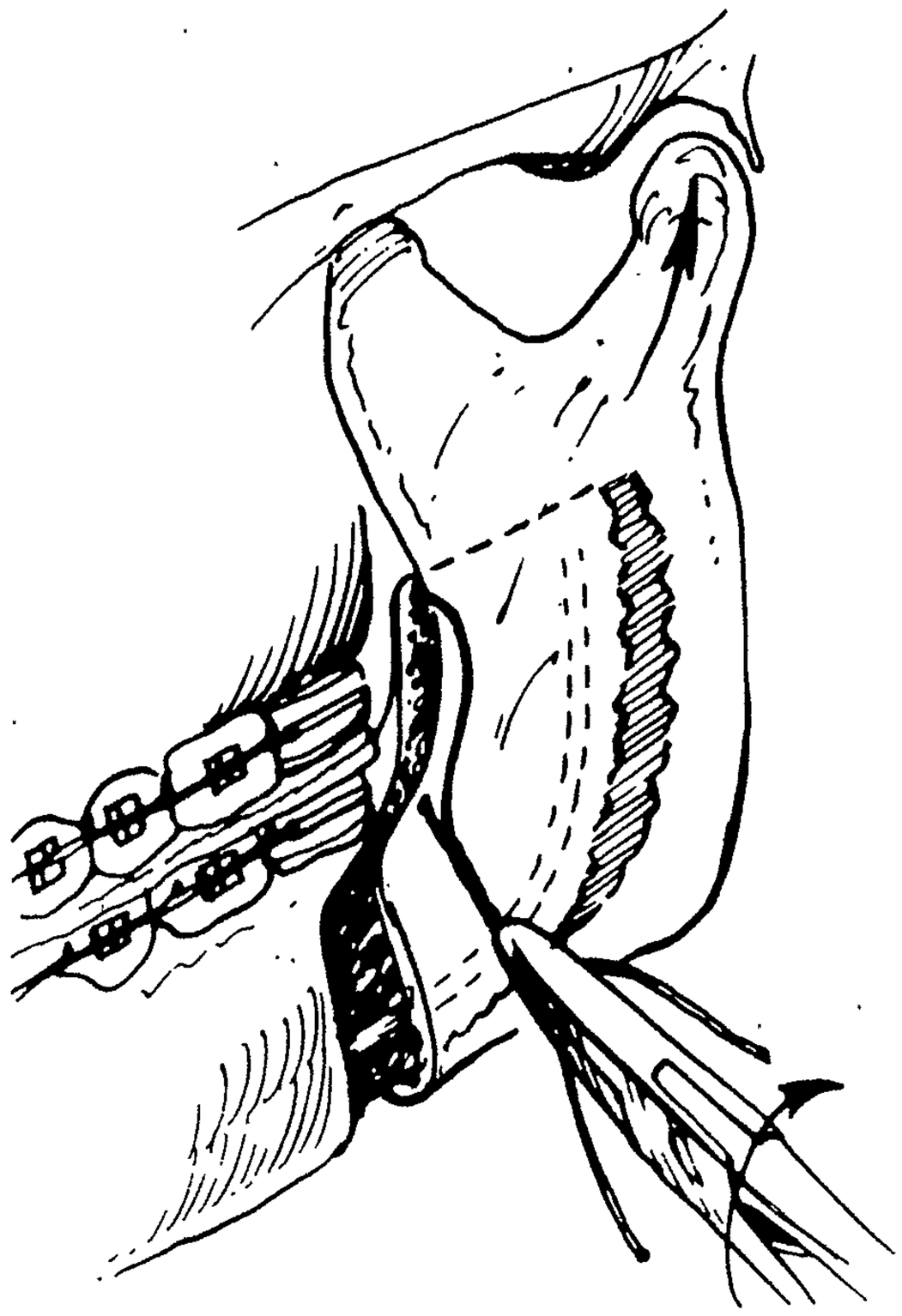
Schuchardt's Inverted L Ramus Osteotomy with interposed Graft, After Schuchardt 1961.

Diagram 70

The "Inverted L" procedure of Trauner and Obwegeser has been used more recently by DiStefano and Spilka for the correction of a relapse after the use of an oblique vertical sliding osteotomy. As the previous surgery had obliterated the sigmoid notch and therefore contra-indicated the re-use of the same procedure, the "Inverted L" procedure was tried and found to be successful. The "Inverted L" procedure was well recommended and found to be indicated by the authors for such occasions of correction of relapse. (DiStefano & Spilka 1978).

Development of the Sagittal Ramus Procedures.

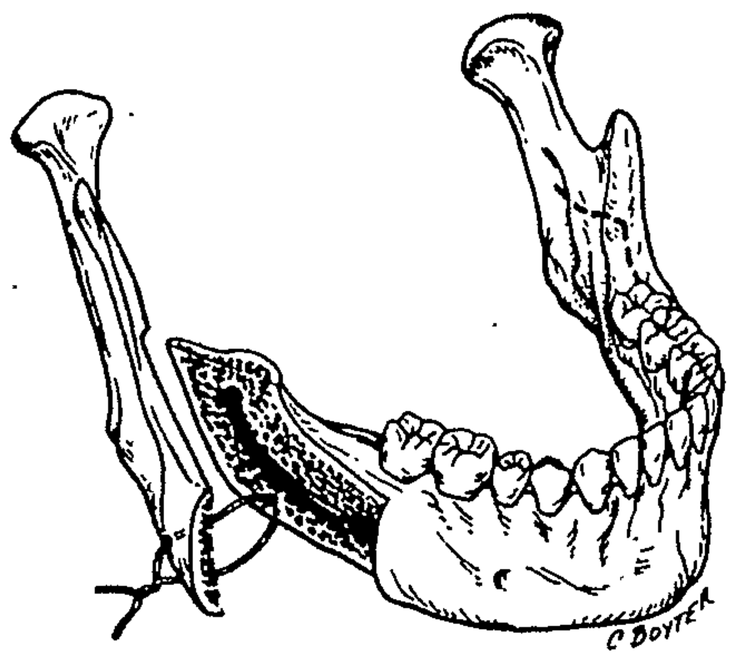
For moderate retrusion, Trauner and Obwegeser recommended their sagittal split procedure without the use of grafts. The distal segment of bone being protruded anteriorly rather than taken posteriorly, there being otherwise no change in the procedure. One advantage of the sagittal split procedure is its flexibility in treating a number of mandibular deformities.



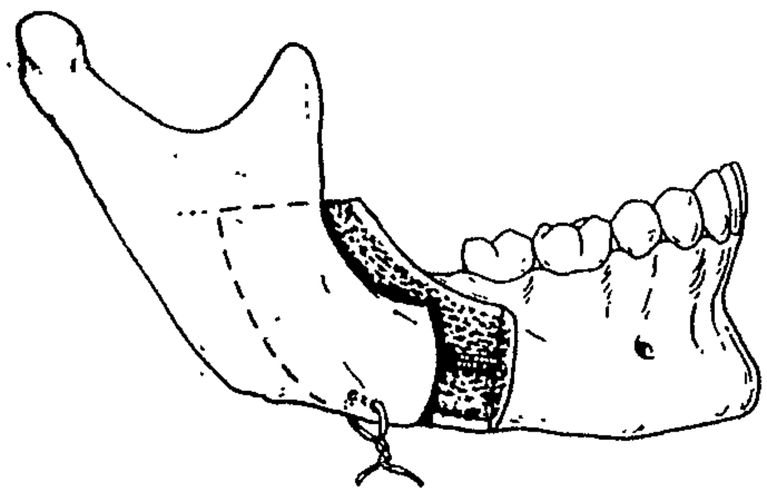
Modified transosseous wiring technique for control of condyle-ascending ramus position described by Epker.

Epker's Modification of the Superior Border Wire Placement for Fixation of Fragments After Anterior Fragment Advancement. After Epker 1977.

Diagram 71



Schematic illustration of inferior border wiring technique.



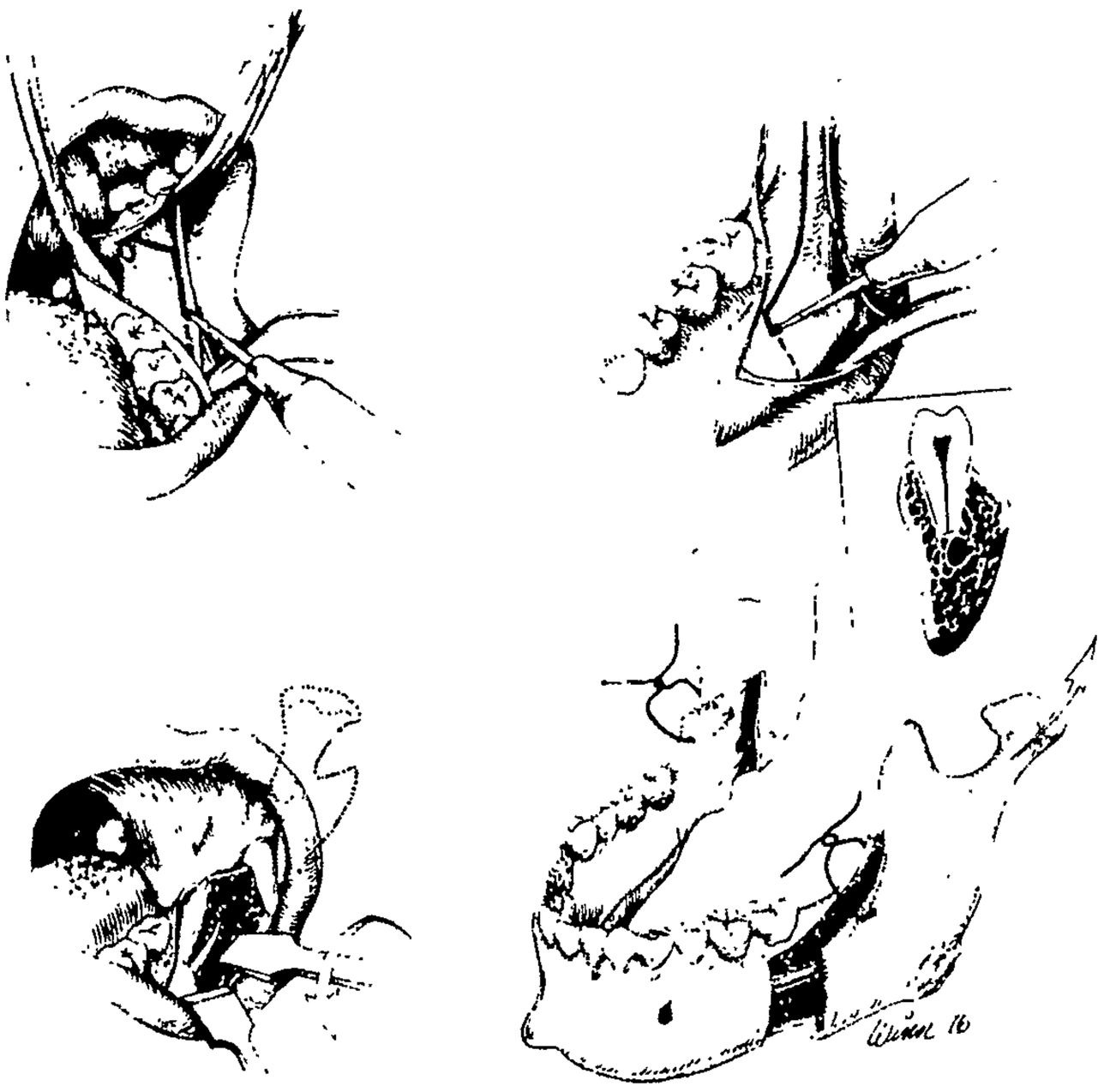
Inferior border wiring technique demonstrating the maintenance of inferior border continuity.

Booth's Inferior Border Wire Placement for Fragment Fixation After Advancement. From Booth 1981.

Diagram 72

Trauner and Obwegeser (Obwegeser 1955, 1957) had originally suggested the use of circummandibular wire to hold the fragments, which Obwegeser later (Obwegeser 1964a) changed to an upper border wire to achieve a more satisfactory seating of the condyle into the fossa while stabilising the fragments (also Dal Pont 1961). This was modified by Epker (Epker 1977) also to satisfactorily seat the condyle. Inadequate seating of the condyle contributes a lot to post-operative relapse immediately after fixation release where there is a large discrepancy between (functional) centric occlusion and (terminal hinge position of) centric relation. See **diagram 71.** Booth (Booth 1981) suggested that to avoid some of the problems of condyle rotation, a lower border wire be placed so that the inferior margins of the fragments be matched up rather than the superior borders as tightening of the wire in the latter case will often cause an undue rotation of the condyle, a problem Epker sought to avoid. See **diagram 72.**

Epker in a report in 1978 (Epker & Fish 1978) reported a modification of the sagittal split osteotomy in order to avoid damage to the mandibular neurovascular bundle, and still obtain maximum extension of the body of the ramus for the correction of moderate to severe retrognathism. Instead of completing the medial section through to the posterior border of the ramus, the section was taken vertically down immediately posterior to the lingula and continues in an arch to meet the lower border below the retromolar region, anterior to the attachment of the Lateral Pterygoid and Masseter musculature. Thus the masticatory muscles were not displaced anteriorly with the advancement of the fragment, and actually helped to decrease the amount of relapse post-operatively by resisting change. An important factor to prevent relapse was the



A modified sagittal osteotomy technique developed by the senior author (B.N.E.).

Epker's Modification of the Sagittal Split Ramus Osteotomy. 1978.

Diagram 73

superior border wire placement described above and shown in **diagram 71.** Use was made of a right angled reciprocating saw through an oral/lingual approach. The neurovascular bundle was identified prior to starting the cut. See **diagram 73.**

Along with many others who looked into the complications and problems of the use of the sagittal split procedure, Freihofer and Petrésevic reported their findings of the suitability of the sagittal split procedure for the correction of retrognathism.

Freihofer and Petrésevic (Freihofer & Petrésevic 1975) working with Obwegeser noted only a high percentage of mental

(Vth nerve) nerve damage as a significant disadvantage. They noted 8% with no sensibility of the nerve, 41% with partial sensibility of the nerve and 51% with complete function of the nerve. This was the initial findings within six months of the operation. Later findings from the same patients followed up at least two years and on average five years post-operatively showed that the 8% with no sensibility was then 2%, partial sensibility had become 20% (from 41%) and full sensibility had become 78% (from 51%). No damage to the Facial Nerve was reported. There was a serious or profuse haemorrhage only once. Relapse or regression tendency was satisfactory to the authors in 90% of cases and unsatisfactory to them in 10% of cases, (i.e. showing 40% or more regression on the original advancement.). Temporomandibular joint pain was present in only one case (2%). Their findings were similar to Pepersack and Chausse (Pepersack & Chausse 1978) who conducted a similar study on patients of Obwegeser's clinic who were treated for prognathism.

Relapse is the most important post-surgical problem in the treatment of retrognathism. Many surgeons have reported on the causes of relapse and discussed methods of overcoming this problem.

Poulton et al. (Poulton, Ware, Baumrind & Crane 1979) examined 20 patients who had a sagittal split procedure performed for the correction of retrognathia. In these cases intermaxillary fixation was maintained for 6 to 7 weeks, followed by a period of at least 4 weeks of elastic (guided) traction with an acrylic splint in position, followed by in some cases, a modified splint full time for additional 10 to 12 weeks and/or a neck brace. Broadly defining their patients into "no relapse" and "large relapse"

groups, all the patients in the "no relapse" group used the neck brace the aim of which was to counteract the pull of the hyoid muscle group on the advanced mandible. Suprahyoid myotomies were not performed routinely, only on those patients where tension prevented the mandible from being placed into its predetermined position.

In their conclusions, Poulton et al. realised that the mandible has a tendency to return to its original position, and that relapse was problem occurring both during and after fixation. (Poulton, Ware, Baumrind and Crane 1979).

Steinhäuser (Steinhäuser 1973) had already recognised the problem of relapse with the correction of retrognathia, and advised routine suprahyoid myotomy when the sagittal split procedure was used to advance the body of the mandible.

Egyedi also recognised the problems of relapse with ramus procedures for the correction of retrognathism and suggested that the mandibular advancement allow for this, even to the point of reversing the nature of the deformity from that of retrognathia to mild prognathism including obtaining a reverse incisor overjet which provides some measure of "locking" and would help to retain the new mandibular position. Thus the expected relapse will place the mandible eventually into its desired position. (Egyedi 1980). All of the cases that Egyedi presented were of severe retrognathism including three cases of Oto-Mandibular Dysostosis.

Epker and Wessberg (Epker & Wessberg 1982) were of the opinion that the two most important causes of relapse were

firstly incorrect seating of the condyle, and reported their superior border wiring technique to overcome this; and secondly connective tissue tension associated with the new mandibular (paramandibular) position, the main subfactor being the periosteum and advised incision of the periosteum and longer skeletal suspension (circummandibular, and piriform fossa or infra-orbital) rather than dental fixation (twelve weeks) to allow adaptation of the tissues. Unless stretched by 30% of their length, the suprahyoid muscles did not become a problem. Both surgeons advised that simultaneous advancement genioplasty not be undertaken unless with skeletal fixation and for longer periods as this only increases the degree of tissue tension and therefore a greater degree of potential relapse.

Epker and Wessberg had noted a number of potential factors contributing to relapse which can be summarised:

Early Relapse

1. Condyle seating into the fossa
2. Orientation of the proximal fragment
3. Paramandibular connective tissue tension
    a. Periosteal tension.
    b. Suprahyoid and other muscle stretching
    c. Skin
    d. Interstitial connective tissues
4. Tooth mobility and extrusion
5. The magnitude of advancement

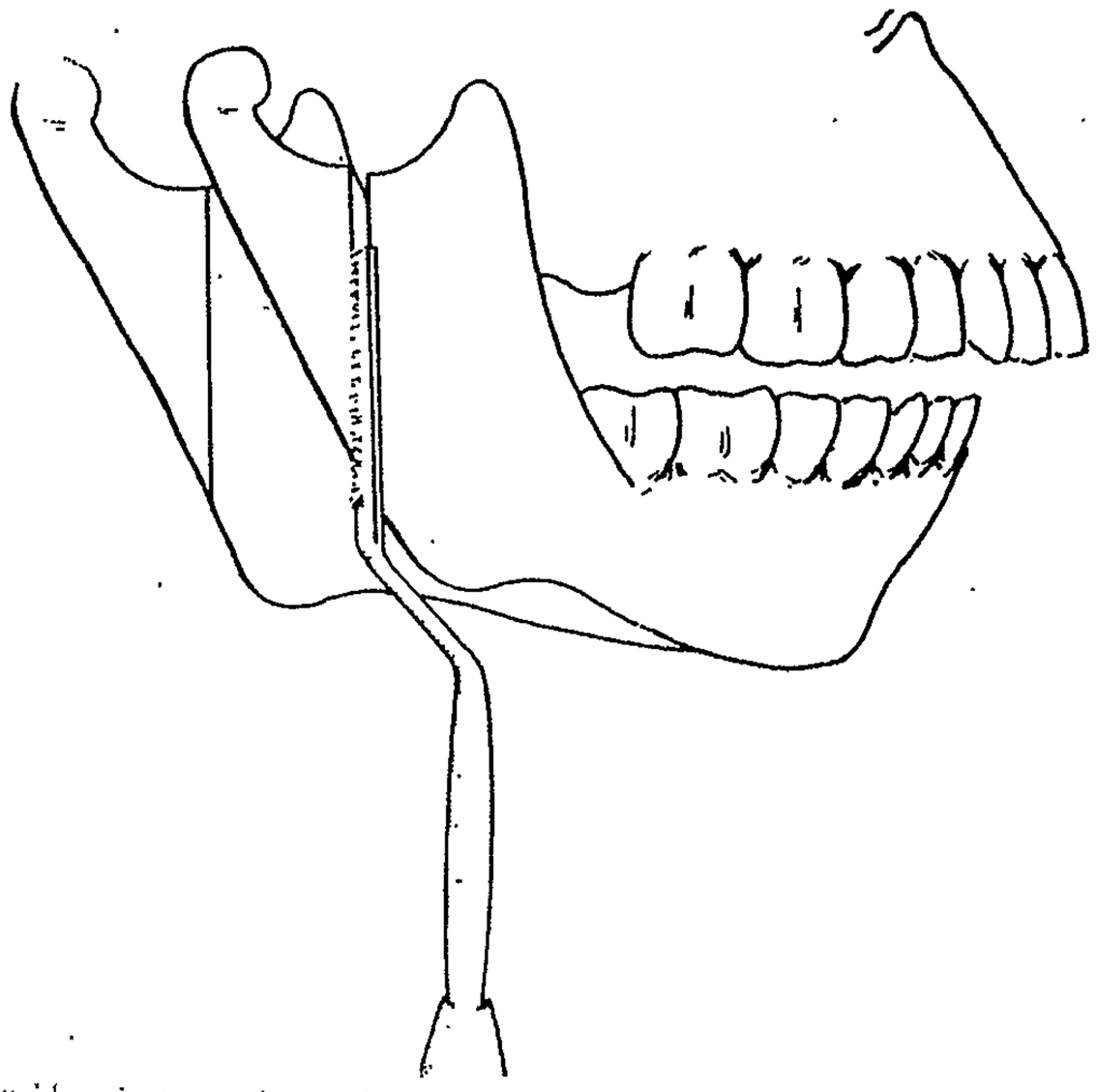
Delayed Relapse

1. Accelerated growth of the posterior maxilla
2. Condyle degeneration
    a. vascular necrosis
    b. degenerative arthritis
    c. condylysis (After Epker & Wessberg 1982)

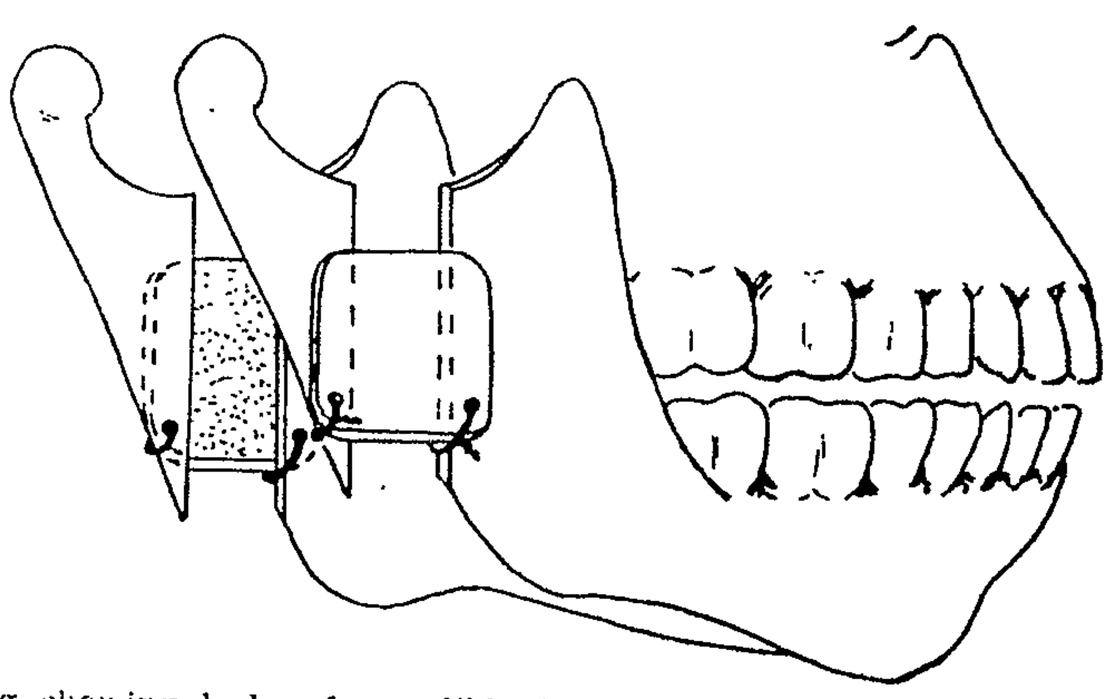
Development of Vertical Ramus Procedures.

In 1954, a year prior to Trauner and Obwegeser's report, a new procedure was reported that was to greatly influence the surgical world in the way that Trauner and Obwegeser did with their sagittal split procedure and has led to a division that has not been removed but increased to this day. The procedure was in many ways the opposite of the Trauner and Obwegeser procedure. Where the sagittal split was approached orally with all the relevant problems of that approach, the new technique was extra-oral with all the relevant problems of that approach, the problems of both approaches have already been outlined; where the Trauner and Obwegeser procedure was in the sagittal plane the new technique was nearly vertical; where the sagittal split procedure required careful bony dissection to free the Mandibular nerve the new technique if properly executed did not directly involve the Mandibular nerve at all. The procedure as already outlined in the chapter on the correction of Prognathism, goes under various names, but the most commonly used name for the procedure is the vertical subsigmoid procedure. What is to follow is the development of the procedure for the correction of retrognathism.

The procedure was reported by Caldwell and Letterman (Caldwell & Letterman 1954). Caldwell and Letterman described their vertical ramus procedure that included decortication, for the correction of protrusion. Caldwell and Letterman suggested that the procedure could be adapted for the correction of retrusion. Robinson (Robinson 1957) did so in 1957 using an iliac crest graft in a preliminary report, and later with bone chips (Robinson 1958). Robinson made his approach using a Risdon type incision approximately six to seven centimetres in length, one centimetre below the angle of



Drawing showing nasal saw being used to make vertical osteotomy of ascending ramus from the deepest portion of the notch to the angle.

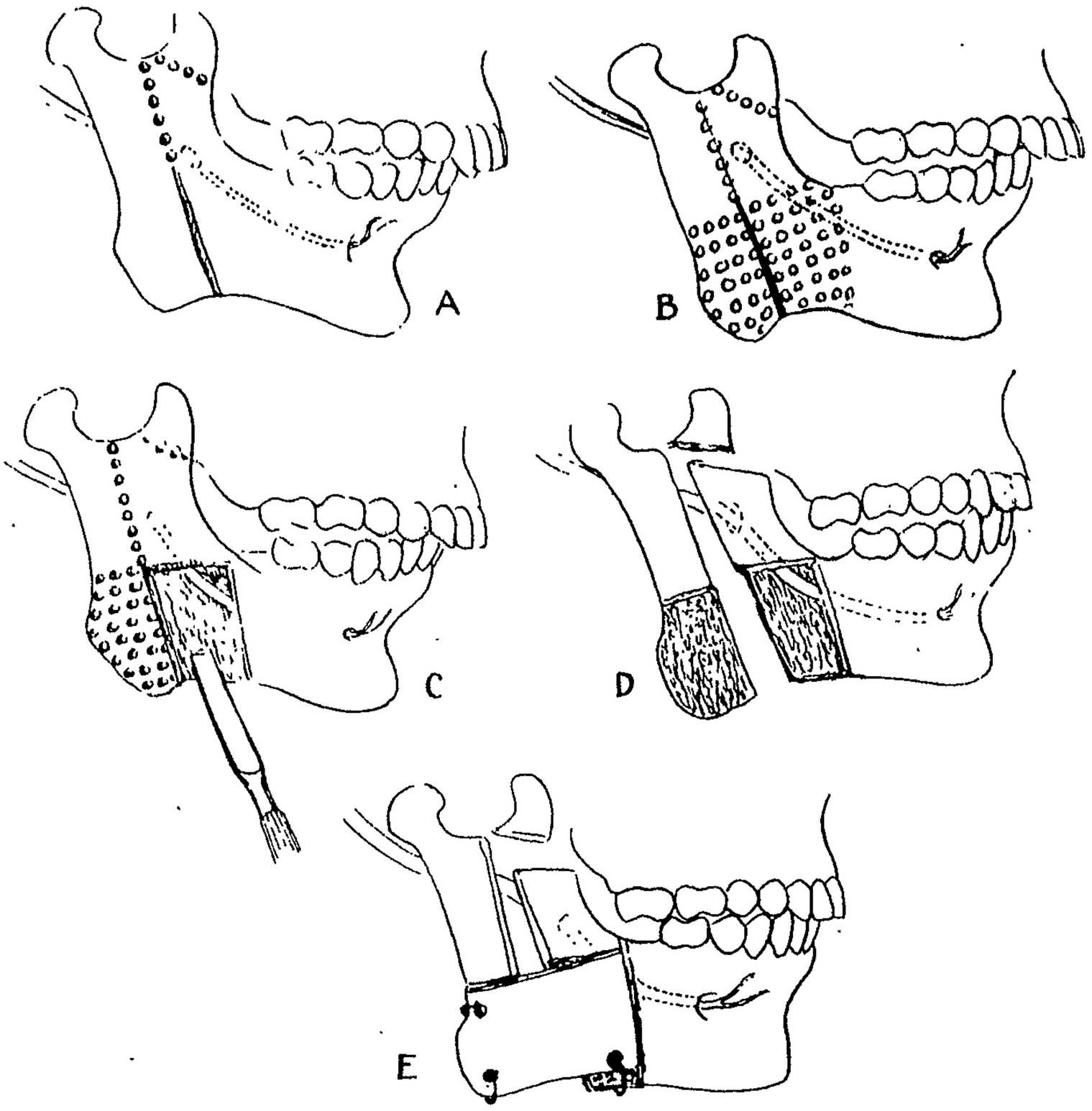


Drawing showing body of mandible in postoperative position and iliac bone onlay grafts immobilized with interosseous wires.

Robinson's Graft (Iliac Crest) to Caldwell and Letterman's Vertical Ramus Osteotomy. From Robinson 1957.

Diagram 74

the mandible. The periosteum was raised until the sigmoid notch was identified and the bone sectioned with a nasal saw. When the bone cuts were complete, the jaws were then immobilised in their new predetermined position and the bone graft from the iliac crest then



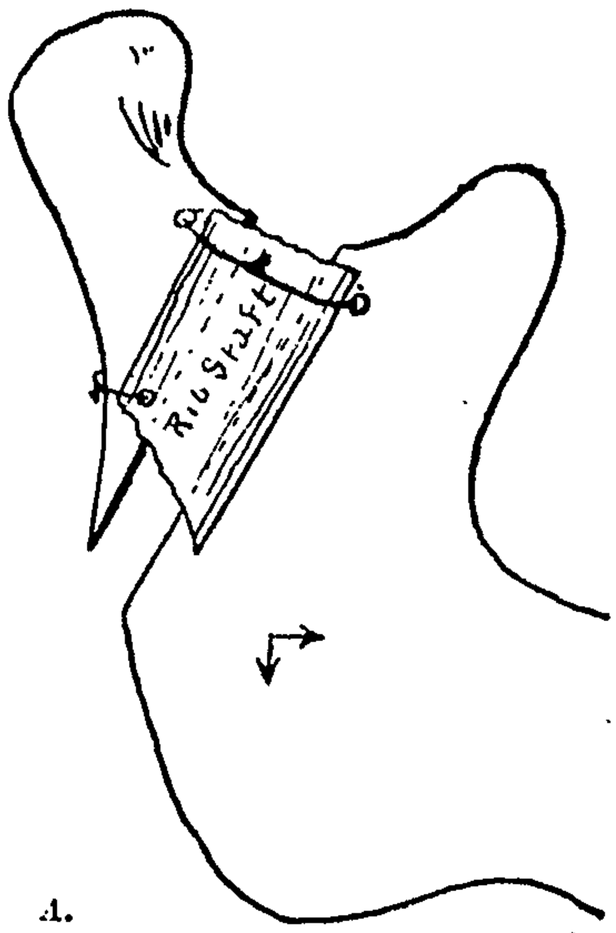
Vertical osteotomy of the ramus of the mandible combined with bone graft for advancement of the body of the mandible. *A*, Lines of osteotomy. *B*, The outer cortex of the mandible in the region of the angle is perforated by multiple drill holes. *C*, The outer cortex of the mandible is removed with an osteotome. *D*, The body of the mandible is advanced after completion of the osteotomy. *E*, An iliac bone graft is wired in position to maintain bony contact between the separated mandibular fragments. (After Caldwell and Amaral.) 1960

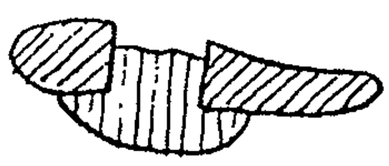
Caldwell & Amaral's Variation of Caldwell & Letterman's Ramus Osteotomy.
After Caldwell & Amaral 1960.

Diagram 75

added to the separated fragments and wired into position. Fixation was for approximately seven weeks. See **diagram 74.**

In 1960 Caldwell published a further variation (Caldwell & Amaral 1960). See **diagram 75.** Caldwell attributed part of the operation design to Robinson's procedure (Robinson 1957). Both Robinson's and Caldwell's procedures were designed for the





Oblique osteotomy in ramus in case of severe retrognathia. Rib graft is used to bridge the gap. *A*, Lateral view showing graft applied and wiring. *B*, Cross section.

Thoma's Graft to Verne, Polachek & Shapiro's Subcondylar Ramus Osteotomy, for Mandibular Advancement.
From Thoma 1961.

Diagram 76

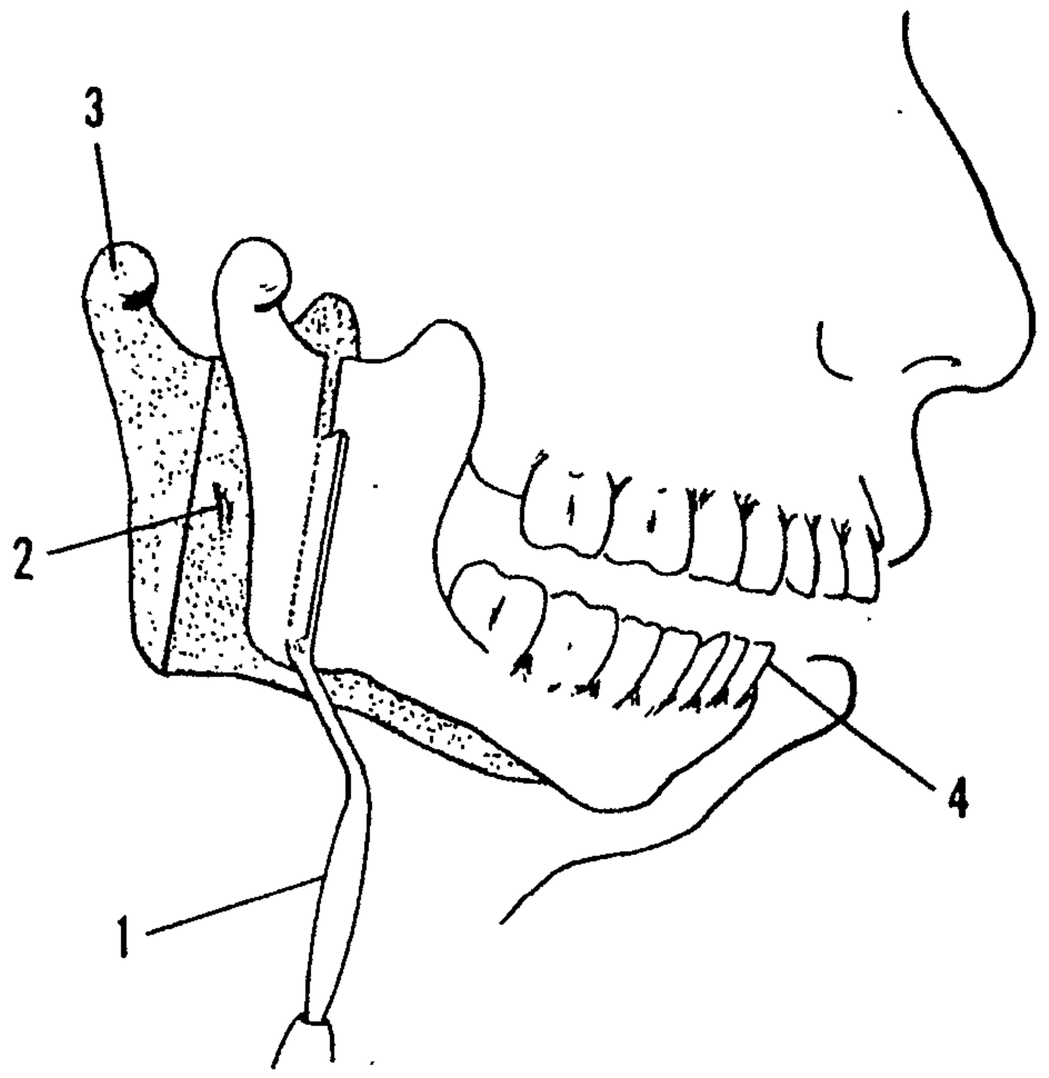
correction of moderate to severe retrusion of the mandible. Both used iliac crest grafts for the bone replacement.

Thoma (Thoma 1961) suggested the use of a costal rib graft for the treatment of moderate to severe mandibular retrusion using the vertical oblique sliding osteotomy developed from Kostecka's procedure but with the later, nearly vertical variation as described by Verne, Polachek and Shapiro. See **diagram 76.** (Verne, Polachek and Shapiro 1957). Converse (Converse 1963) reported using the purely vertical procedure interposing rib grafts to achieve the degree of protrusion required to correct the retrognathic mandible.

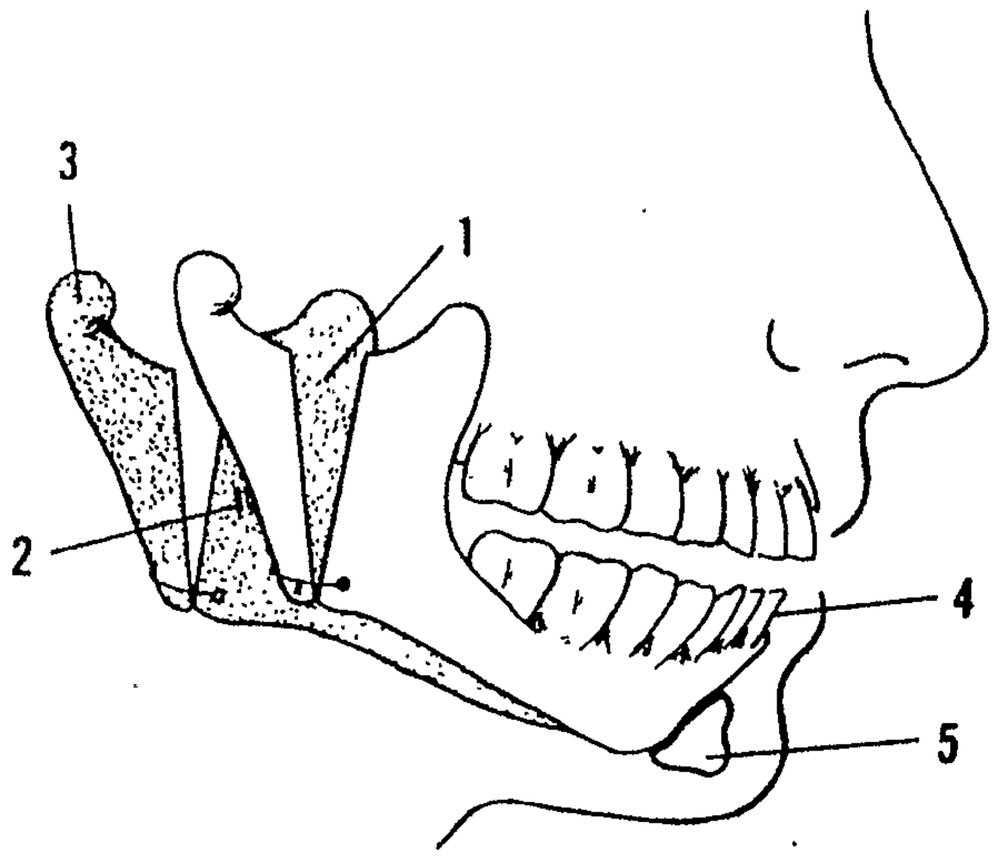
Popesçu and Vasiliu (Popesçu & Vasiliu 1975)

demonstrated the various ways that vertical and non-vertical osteotomies of the ramus of the mandible can be used to reduce retrognathia in the moderate to severe case. In the moderate case, where grafting is not required, the authors recommended a blind approach with a Gigli saw to achieve a vertical sectioning of the ramus and consequently resetting the body of the mandible forwards and maintaining the fixation with elastic traction. This was best used, according to the authors, in cases of either unilateral retrusion of the mandible, or cases where the problem was due to a shortening of the ramus. Where grafting was required then exposure of the mandible through a submandibular incision was recommended. Iliac crest bone was preferred and used. Combination ramus sections included a vertical cut with a horizontal cut above the lingula to free the coronoid process where the anterior displacement was very large and the Temporomandibular Joint was ankylosed, also a vertical section combined with a resection cut of the gonial angle where the angle is greatly exaggerated. The resected gonial angle was used as a graft filling the bony gap when the anterior fragment was advanced. Popesçu and Vasiliu recommended the sagittal split procedure where the retrognathism was mild and the mandible was essentially normal in architecture.

In order to avoid the use of a graft, Robinson and Lytle (Robinson & Lytle 1962) described a procedure whereby retrusion of the mandible could be corrected by a vertical osteotomy cut. This method produced a "V" shaped gap between the corrected fragments, which was covered on both sides with periosteum and was allowed to eventually fill up with bone. Fixation of the fragments was obtained by interosseous wiring at the angle of the "V" at the lower border, and by intermaxillary wiring. See **diagram 77.** Robinson and Lytle



Drawing of retruded mandible. *1*, Saw in position for vertical osteotomy. *2*, Mandibular foramen. *3*, Condyle. *4*, Malocclusion due to micrognathism.



-Drawing of mandible after surgery. *1*, Defect which fills in with new bone. *2*, Mandibular foramen. *3*, Condyle. *4*, Corrected occlusion. *5*, Cartilage graft.

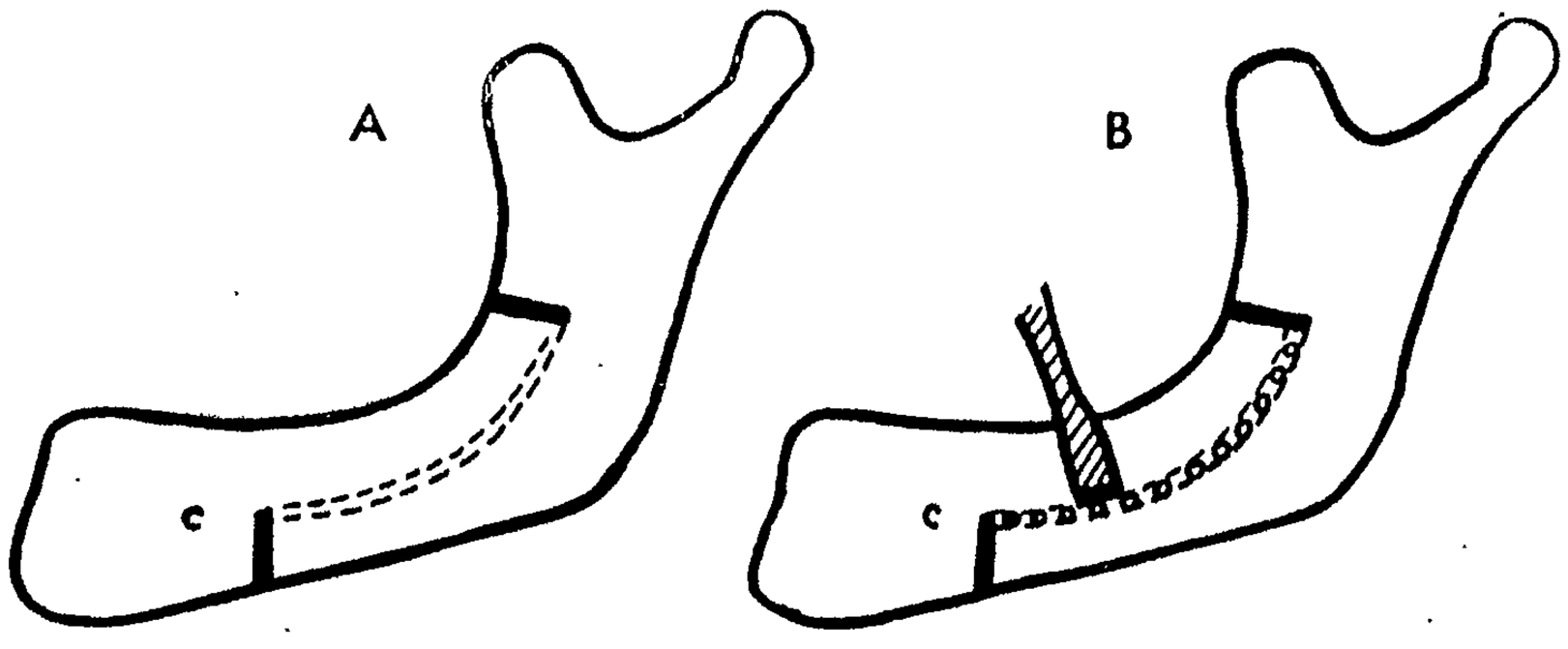
Robinson and Lytle's "V" Ramus Osteotomy.
From Robinson and Lytle 1962.

Diagram 77

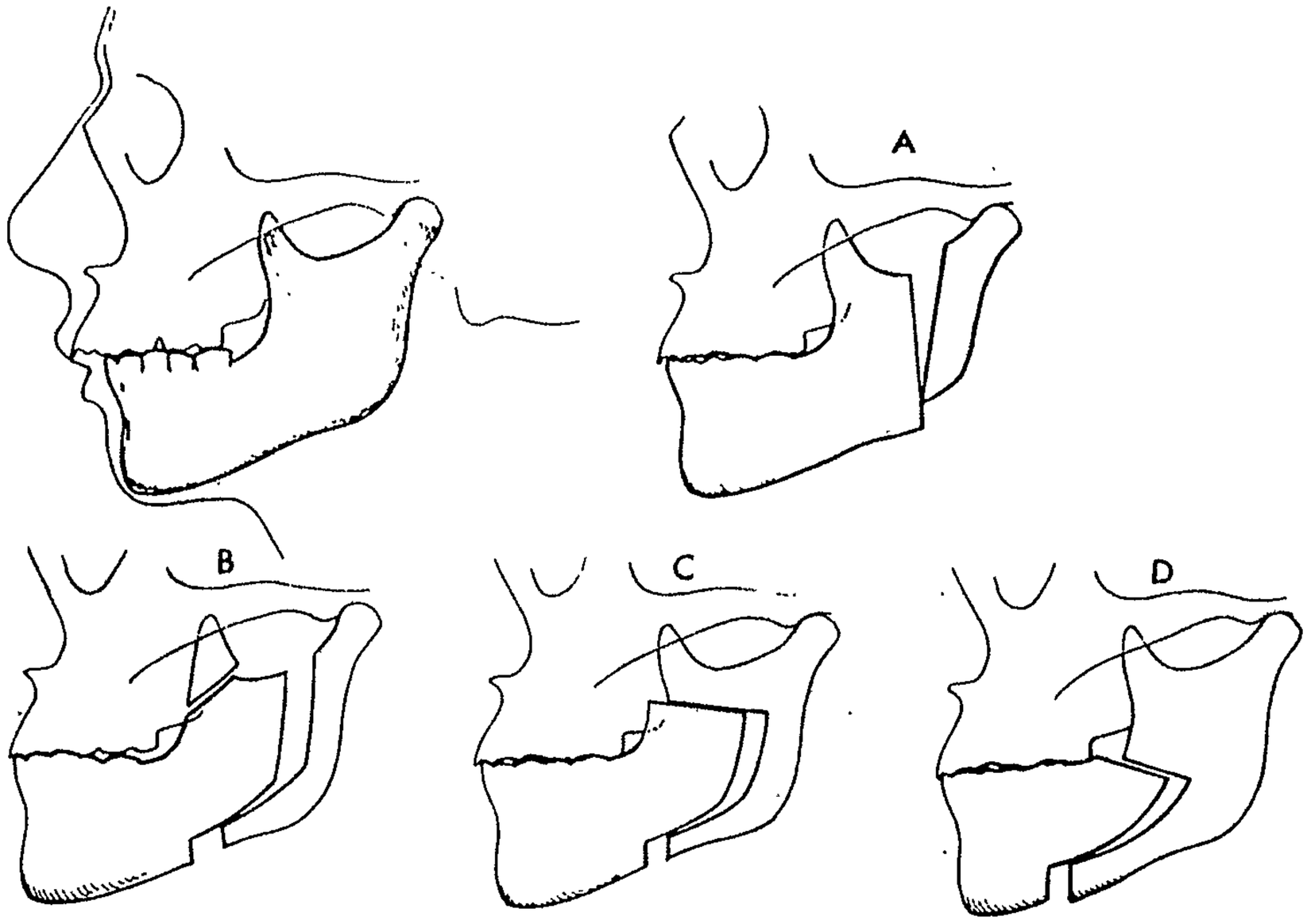
recommended that this procedure be performed on cases of severe retrognathism (micrognathism). Fourteen cases were operated on over a four year period and healing was uneventful in all fourteen cases. Robinson and Lytle attributed this to the lack of stress on the osteotomy site and that the defect is covered with periosteum both medially and laterally. The fixation period for this technique was up to three months (twelve weeks) due to the large amount of bone that had to form to fill in the "V" defect and make the fracture stable. This disadvantage is the main reason for the unpopularity of the procedure. The other disadvantage was the need to rotate the condyle forward in the fossa to maintain contact at the angle.

A further attempt to avoid the use of a graft was Caldwell's "Sliding C" osteotomy for the correction of mild to moderate retrusion. Instead of completing the inferior part of the cut against the posterior border after Wassmund's "S"osteotomy, Caldwell continued his inferior portion of the cut well anteriorly into the body of the mandible to finish as a taper to the lower border or as short sharp right angled turn. See **diagram 78.** With this procedure grafting is not required unless the required forward shift is very large and the periosteum is unable to cover the resultant defect. (Caldwell, Hayward & Lister 1968). This procedure has the advantages of; (a) not disrupting the dental arch, (b) of having good bony contact adequate for rapid union and therefore minimising relapse, (c) the pterygo-masseteric sling is substantially intact further decreasing post-operative relapse and allowing the condyle to remain in a good position, (d) it should be possible to avoid the mandibular neurovascular bundle.

Using instrumentation developed by Hinds (Hinds &



--Stages of arc section osteotomy for mandibular advancement.



Types of bone section in mandibula advancement. A: Procedure in which section is taken from sigmoid notch to angle; bone graft has been frequently interposed. (This procedure is no longer recommended.) B: Section taken from sigmoid notch with anterior extension and coronoidotomy. C: Combined ramus and body arc step section for advancement of mandible. D: Step section at low level. Section is brought parallel to the arc of movement of the mandibula anterior teeth to maximize bone contact.

From Caldwell, Hayward and Lister 1962.

Diagram 78

Girotti 1967; Hebert, Hinds & Kent 1970) for the intra-oral vertical oblique sliding osteotomy, Levine and Topazian performed the "Inverted L" osteotomy intra-orally. They showed that is is possible to overcome one of the disadvantages of the vertical procedures and that is the need to use an external approach. All other approaches had been extra-oral with the exception of Trauner's procedure which was a mixture. (Levine & Topazian 1976).

Garrett, Quinn & Pickrell tried an unusual approach when they stripped every attachment off the mandible, and then placed the mandible in traction for eighteen days, followed by splinting for three to four weeks. A six year follow-up showed good stable results. The procedure was recommended for severe cases only. There was no mention of the effects of the traction on the Temporomandibular joint and its function. (Garrett, Quinn & Pickrell 1968).

Summary.

Relapse and insufficient correction (lack of bone) still constitutes the biggest problem in the treatment of retrognathism. Ramus procedures are still preferred to body procedures at this point of time for those main reasons.

The early horizontal ramus procedures were not successful due mainly to post-operative open bite, relapse and non-union attributable to small area of bony contact and unfavourable muscle pull. Developments from this point tried to avoid these problems. The developments succeeded in different ways with different emphasis on the various advantages. The horizontal osteotomies became oblique or angled and to eventually culminate

firstly in the sagittal ramus procedure with its vastly increased bony contact and secondly the oblique vertical osteotomies with a good record for lack of complications and good stability. Examination of the literature would indicate that the commonest procedure preferences are generally either a variation of the vertical procedures or a variation of the sagittal split procedures.

Hinds and Kent (Hinds & Kent 1972) recommended ramus procedures in general and the vertical osteotomies in particular, for the following reasons:

1. Advancement of the mandible (using ramus procedures) even in extreme cases with a graft is not difficult.
2. Fixation of the fragments is easier than body procedures.
3. Union is more rapid than body procedures.
4. Cosmetic improvement of the angle is possible.
5. The surgery is easier in nature with respect to access.
6. (Referring to the vertical procedures in particular). There is a lack of involvement of the mandibular nerve.
7. The good blood supply to the area ensures a greater probability of any graft taking.

There are disadvantages to the use of the vertical procedures for the correction of retrognathism that are not often mentioned:

1. The greater need to use grafts than with the sagittal split procedure due to lesser bony contact with the vertical procedures.

2. The time taken to secure the graft adds to the operating time.

3. The requirement to do and the time necessary to perform a coronoidectomy with the vertical procedures which is not necessary with the sagittal split procedures.

These are minor disadvantages but not often mentioned.

The advantages and disadvantages of the sagittal split procedure were discussed in the main text but generally the disadvantages are that there is a greater complication rate especially with the mandibular nerve and with relapse usually associated with improper placement of the proximal fragment in particular the relationship of the condyle to the condylar fossa. Advantages are that there are good healing times, far less need for the use of a graft to obtain good correction of retrognathism and finally the lack of external scarring.

The choice of procedure must come down to operator proficiency in the technique of choice and the needs of the patient and therefore the suitability of the procedure for the patients problem.

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MANDIBULAR RETROGNATHISM

Body Procedures

Introduction.

The earliest of the body procedures for the correction of retrognathism were developed for the correction of retrognathism only. Some procedures, such as Blair's 1907 procedure, were adapted from procedures used for the correction of prognathism. But it was the need to develop stable lengthening procedures with increased bony contact that led to the development of the step osteotomies as distinct from the simple section osteotomies. In contrast to procedures for the correction of prognathism, procedures for the correction of retrognathism, performed through the body, were of a step like nature.

As the need for further extension of the body with greater stability became evident, grafting as a supplement, traction with grafting or traction by itself was tried. Grafting became a well documented and used adjunct to extension body procedures, whereas, except for the occasional report, traction based procedures declined.

Simple body procedures, simple sectioning of the body either as a vertical section or a variation of an oblique section gradually became more prominent. The vertical section did not remain long due to problems with non-union, insufficient extension and instability of the fragments. Instead there were many reports detailing variations of the simple body section such as oblique sections, with or without step-like additions, and "Y" body

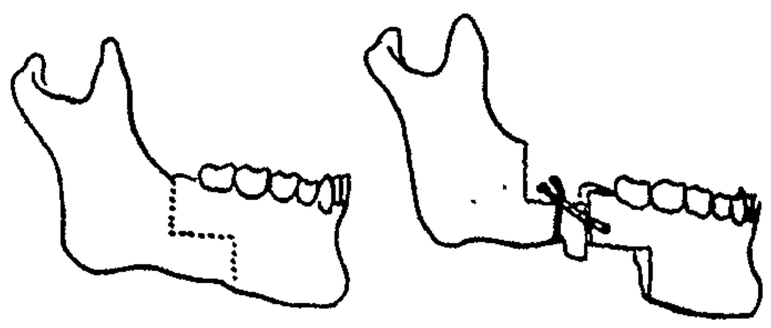
sections, that could often correct concurrent problems such as open bite deformity.

The need for the preservation of the neurovascular bundle became apparent at the same time as it did for the procedures that correct prognathism. Procedure variations were reported that maintained the function of the mandibular nerve. But as discussed in the chapter on body procedures for the correction of prognathism, the question has not been completely resolved even today. This is also discussed.

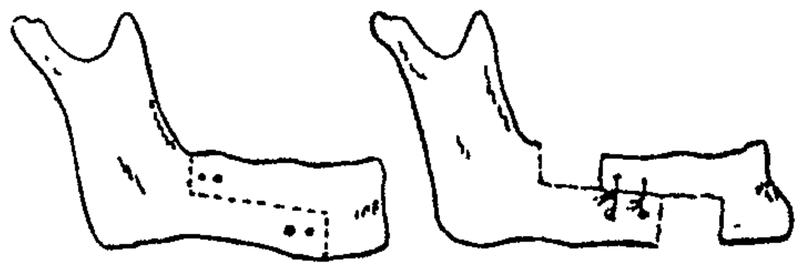
Of all the types of body procedures, it is the step osteotomy that has stayed the longest, and has undergone a reappraisal in the 1980's.

Discussion.

The earliest report was in 1906 (Eiselsberg 1906) who reported two step procedures. The first was a symphyseal procedure for expanding the arch laterally and not relevant to this chapter. The second procedure was a step osteotomy where the ends of the sectioned bone were butted together to allow a large amount of protrusion but with a very much decreased depth to the mandible. The fragments were wired together. See **diagram 79.** At the same time Pehr Gadd (Pehr Gadd 1906) performed the same procedure but kept the fragments overlapped and not butted producing more stable fragments but with a lesser but still large ability to correct retrognathism. See **diagram 80.** Both authors were cited by Limberg (Limberg 1928) and Hensel (Hensel 1937) but with no detailed reference given for the latter author (Pehr Gadd).



Eiselsberg's Step Body Osteotomy. 1906.
From Limberg 1928.



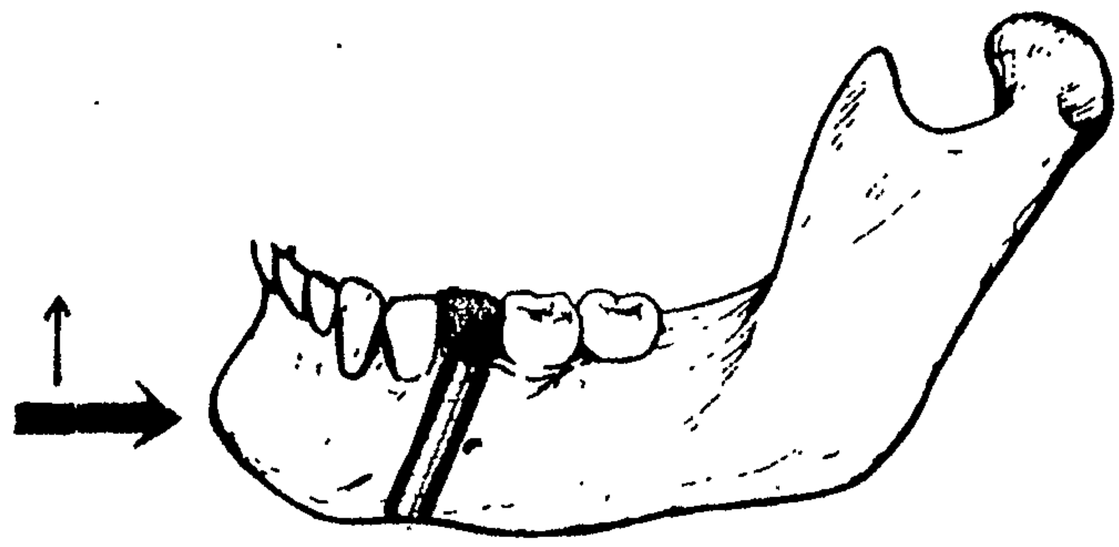
Osteotomy (Pehr Gadd method).

Pehr Gadd's Step Body Osteotomy. 1906.
From Limberg 1928.

Diagrams 79 & 80

Nicolsky (Nicolsky 1912) repeated Eiselsberg's procedure and recommended that interosseous wires be used to ensure stability of the fragments.

Correction of retrognathism was the original stimulus for the development of step osteotomies of the body, and not used for the correction of prognathism until later (Pichler 1918). While there were simultaneous efforts to use simple body sections, oblique or otherwise for the treatment of retrognathism, they were not for the most part as successful as the step procedures.

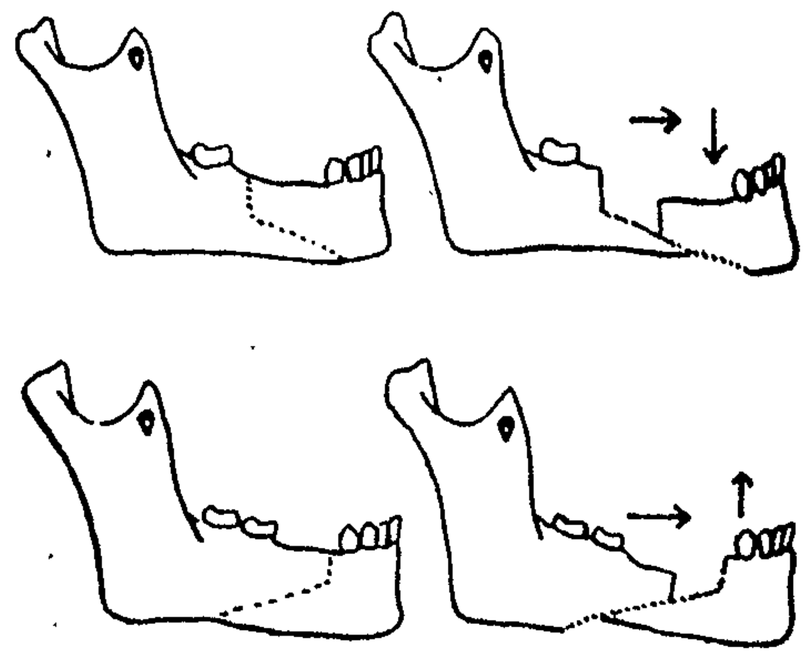


Blair's Oblique Body Osteotomy.
After Blair 1907

Diagram 81

Blair (Blair 1907) reported using an oblique body section for the correction of retrusion with accompanying open bite, see **diagram 81,** but preferred and recommended that ramus procedures be used for the correction of retrusion. Blair also suggested for future use that a graft be used to carry the mandible forward, but no cases were reported.

Eiselsberg and Pichler (Eiselsberg & Pichler 1912) described a variation of the oblique body osteotomy that could be called a sliding step-like osteotomy for the simultaneous correction retrognathism and either open or closed bite. The angle of the cut could be varied to suit the degree of deformity. Both sections commenced with a small vertical cut, followed by an oblique cut the



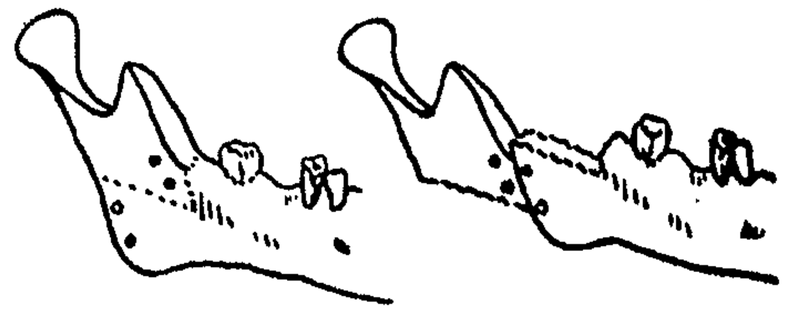
Eiselsberg's & Pichler's Oblique Body Osteotomies.
After Eiselsberg & Pichler 1912.
From Limberg 1928.

Diagram 82

angle and direction of which depended on the accompanying degree of open or closed bite as well as the degree of retrognathism. See **diagram 82.** There was no attempt to preserve the neurovascular bundle.

Limberg (Limberg 1928) also reported the use of the same step-like body cut similar to Eiselsberg and Pichler's osteotomy. Limberg was also responsible for developing a grafting procedure for the correction retrognathism through a body procedure. This will be discussed later in the chapter.

Nicolsky (Nicolsky 1912), Bruhn and Lindemann (Bruhn 1921; Lindemann 1920) reported using a step osteotomy in reverse that involved as much of the ramus as the body. See **diagram 83.** The procedure was performed via an extra-oral approach and sacrificed the neurovascular bundle. The fragments were butted together not unlike Eiselsberg's and also wired together. This



Nicolsky (1912) & Bruhn-Lindemann's (1921)
Reverse Step Body Osteotomy.
From Limberg 1928.

Diagram 83

procedure, while achieving an extremely large correction of retrognathism, would have been very unstable for a number of reasons:

1. Unless the entire musculature of the ramus were stripped off, relapse would have been very significant.
2. There was a substantial decrease in the vertical dimension of the face, the lower third in particular.
3. The gonial angle was reset approximately halfway up the posterior border of the ramus.
4. The amount of correction obtainable was defined by the width of the ramus, unless the original gonial angle was reduced.
5. There was not a large amount of bone contact with the butted fragments, thus union would have been at risk, and union time increased.

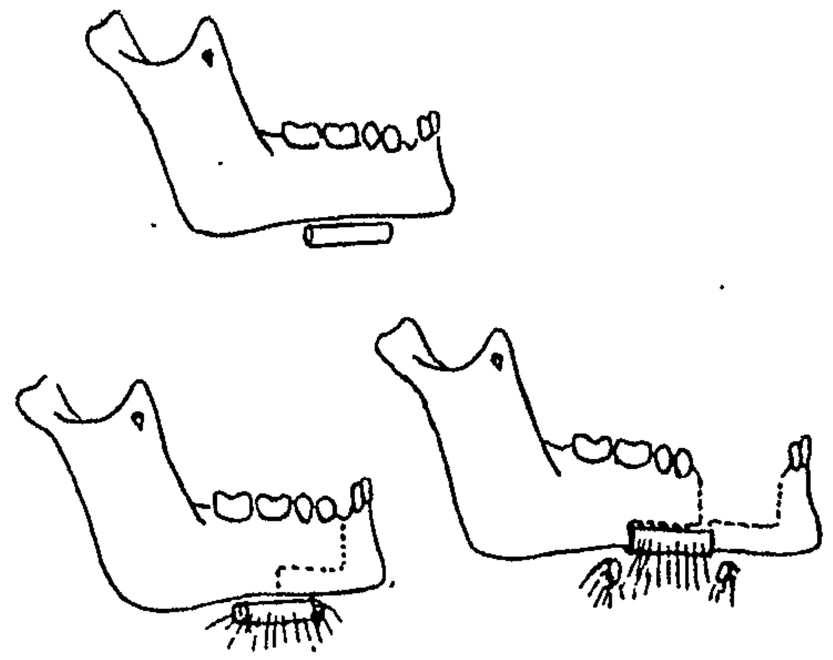
There have been no further reports on this procedure.

Bone grafting and subsequently traction and grafting started to become prominent for a while. Brown (Brown 1928) reported using a simple vertical body osteotomy via an oral approach with the fragments separated by as much as half-inch and held apart until healing with strong arch bars, or until a graft is added later where the gap is large (Lindemann 1920). This report is included to

demonstrate the problems of making up for deficient bone when the body of the mandible was lengthened. This was a period during the late 1910's and into the 1920's when in an attempt to make up for the bone deficiency, traction to the body of the mandible was attempted. The first reports were by Bruhn (Bruhn 1920; 1927; 1928) and Lindemann (Lindemann 1920) who reported a vertical body section via an extra-oral approach (which was simply a lower border cut-down approach as distinct to a Risdon type approach), which was followed by a period of traction using a massive traction appliance, fitted to the head. The latter acted as the anchorage and was similar in appearance to a box frame for middle third fracture fixation. The traction was applied over a four week period. The appliance could also be adapted for correction of open bite.

Again Limberg (Limberg 1928) featured in the development of body procedures for the correction of retrognathism by similarly advocating traction applied for either procedures for the correction of retrognathism, in which case the traction is applied bilaterally, or for the correction of asymmetry, in which case the traction is applied unilaterally. The degree of correction required determined whether a subsequent graft was used after the period of traction. Limberg used traction not only on the grafting procedure he reported, but with other procedures as well where he thought the degree of retrognathism, micrognathism or asymmetry, required it.

At the same time Limberg reported a sophisticated advance for the correction of retrusion. See **diagram 84.** The procedure was in two stages and involved one of the earliest uses of grafting for the correction of retrognathism. The first stage of the procedure required an extra-oral approach to the lower border of the

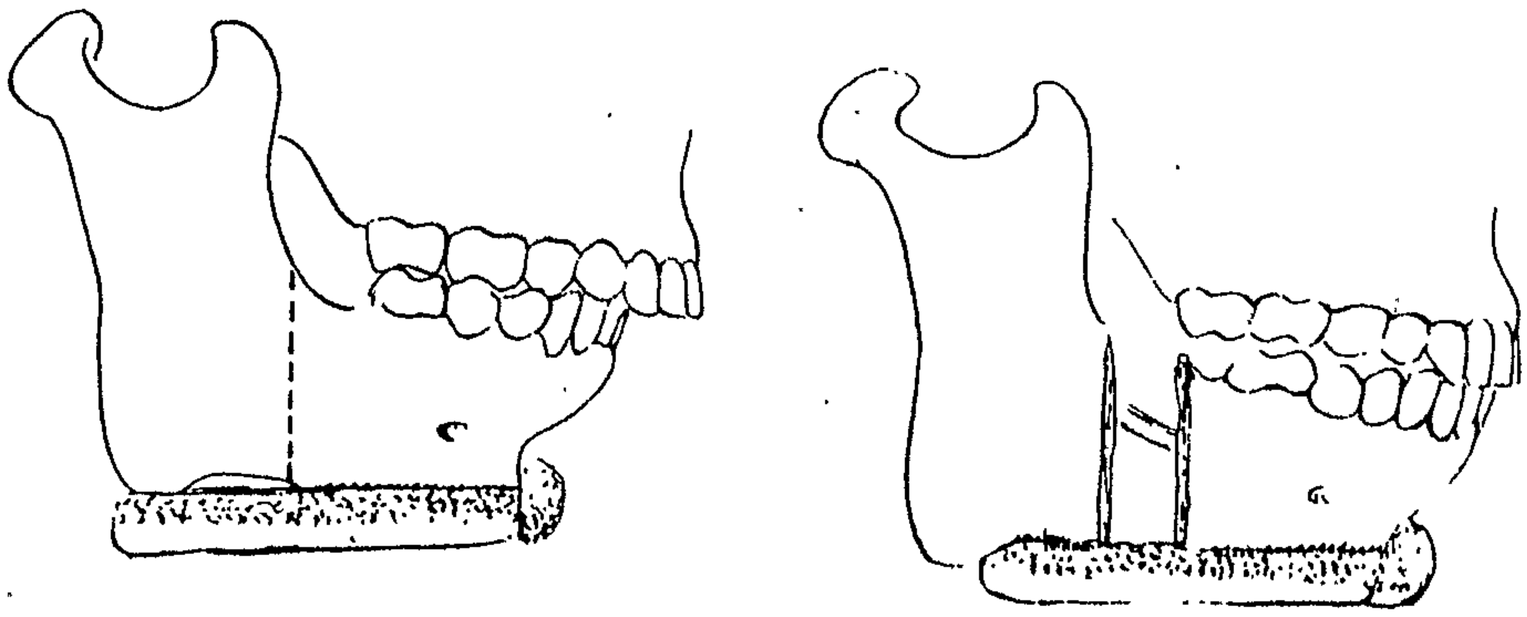


Case in which a steplike osteotomy permitted use of a pedunculated bone graft.

Limberg's Step Body Osteotomy with Sub-periosteal Graft.
From Limberg 1928.

Diagram 84

mandible and the placing of a costal graft to the lower border under the periosteum of the mandible in the region of the second stage osteotomy cut. The graft also had its own periosteum attached. The second operation takes place about two to three months after the first stage. The second stage procedure involved two sub-stages. The first under a local anaesthetic, a mucosal incision is made in the area of the osteotomy cut. The second sub-stage is a dissection through the old external wound to the graft which is also dissected free from the mandible but still pedicled to the periosteum of the mandible. The section cuts are made (a reverse step osteotomy) and completed. The operator then returned to the mouth to wire the lower fragments to the upper jaw in their desired positions and the operator returned to the external wound and the pedicle bone graft is shaped and inserted into the section gap. The multi-staged procedure had one very big advantage in the days of no or limited antibiotics and that was that the graft had a much higher expectancy of survival. An important factor then but not now. (Limberg 1928).



Ginestet's "Drawer" Body Procedure. 1939.
From Converse 1963.

Diagram 85

The traction advancement procedures were also recommended by Axhausen (Axhausen 1939) who preferred Limberg's procedure, and later by Converse (Converse, Horowitz and Wood-Smith 1968) and Merville (Merville 1970). In part due to the cumbersome nature of the traction appliances, also the number of stages required to complete the correction, and the time taken to achieve the desired repositioning, these procedures are no longer common although still reported from time to time.

Following the advice of Blair and as an advance on Limberg's procedure, Ginestet (Ginestet 1939) reported his unusual "drawer" procedure. See **diagram 85.** The surgery was performed in two stages. The first being to place a piece of bone against the lower border of the mandible in a similar manner to Limberg but with a larger piece of long bone. The second stage required a simple vertical cut in the retromolar region and the freeing of the graft from the posterior fragment. The anterior fragment was taken forward with the attached graft. The anterior fragment was wired to the

maxilla and the lower border of the posterior fragment rewired or simply freshened to allow re-attachment of the graft. The bone graft was still in contact with the posterior fragment even when the anterior fragment was shifted forward. The graft was not designed to move into the section gap. The second stage was about two to three months after the first. Every attempt was made to preserve the neurovascular bundle. Where the degree of retrusion was severe, there was sometimes an intermediate stage where traction was placed on the anterior fragment. In that case the osteotomy cuts were placed in the first stage and not the second.

After 1939 there was a very gradual decline of the step procedures for a while, there were still some procedures reported, and instead the simple body procedures were examined, reported and gained favour for the while. Preservation of the neurovascular bundle became the more important topic for discussion.

Kazanjian (Kazanjian 1928) repeated and modified Blair's (Blair 1907) and Limberg's Limberg 1928) oblique body osteotomy for the correction of either open bite or closed bite with retrusion. This time there was a successful attempt to preserve the mandibular neurovascular bundle. This was the first recorded attempt to do so for the correction of retrusion.

Kazanjian (Kazanjian 1936) reported a body procedure that was designed to give as much bony contact between sectioned fragments as possible to allow for the most rapid healing and therefore to have the maximum stability. The section cut was commenced in the region of the premolars and proceeded downwards for approximately one centimetre. The section then proceeded

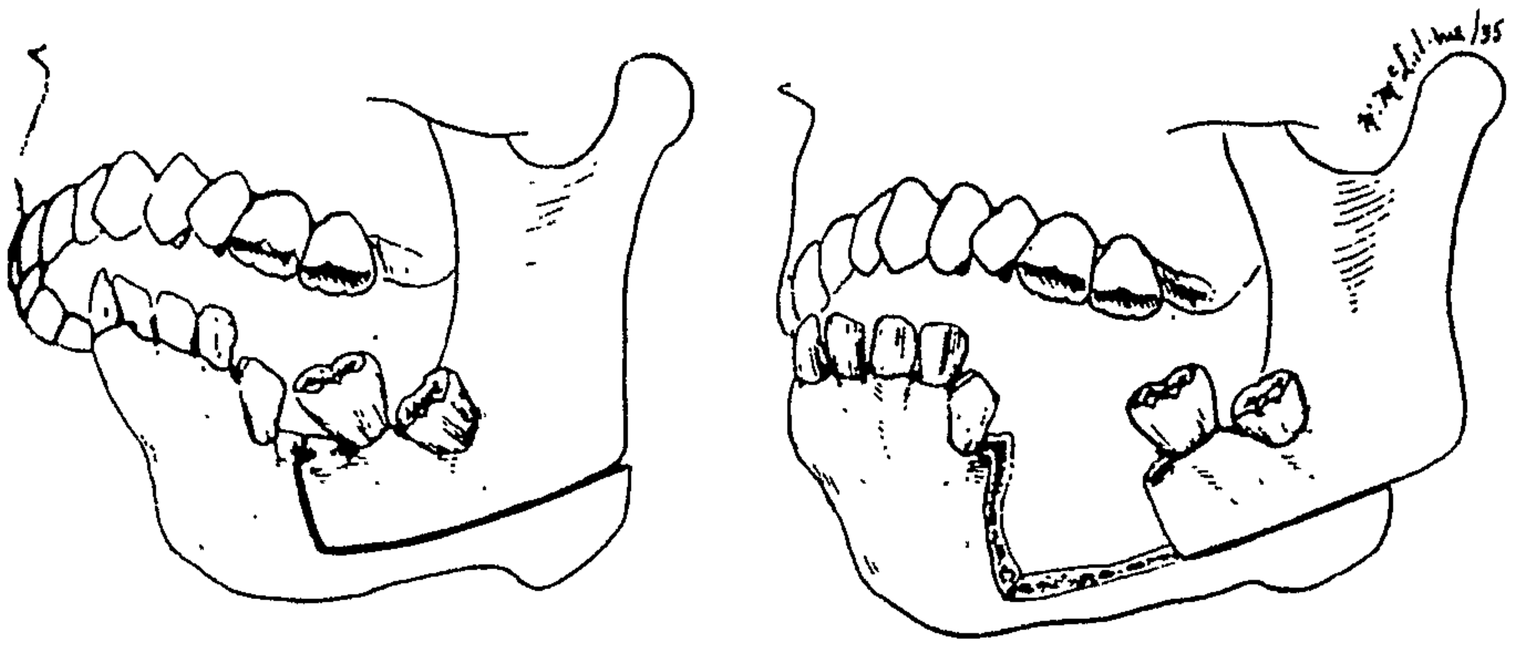


Diagram showing method of elongating the mandible.

Kazanjian's Step Body Osteotomy. From Kazanjian 1936.

Diagram 86

horizontally backwards to finish on the posterior border of the ramus. The fragments were then slid along in contact with each other, the anterior fragment being taken forward, and the fragments wired in the desired position. There was little attempt to preserve the neurovascular bundle. See **diagram 86.**

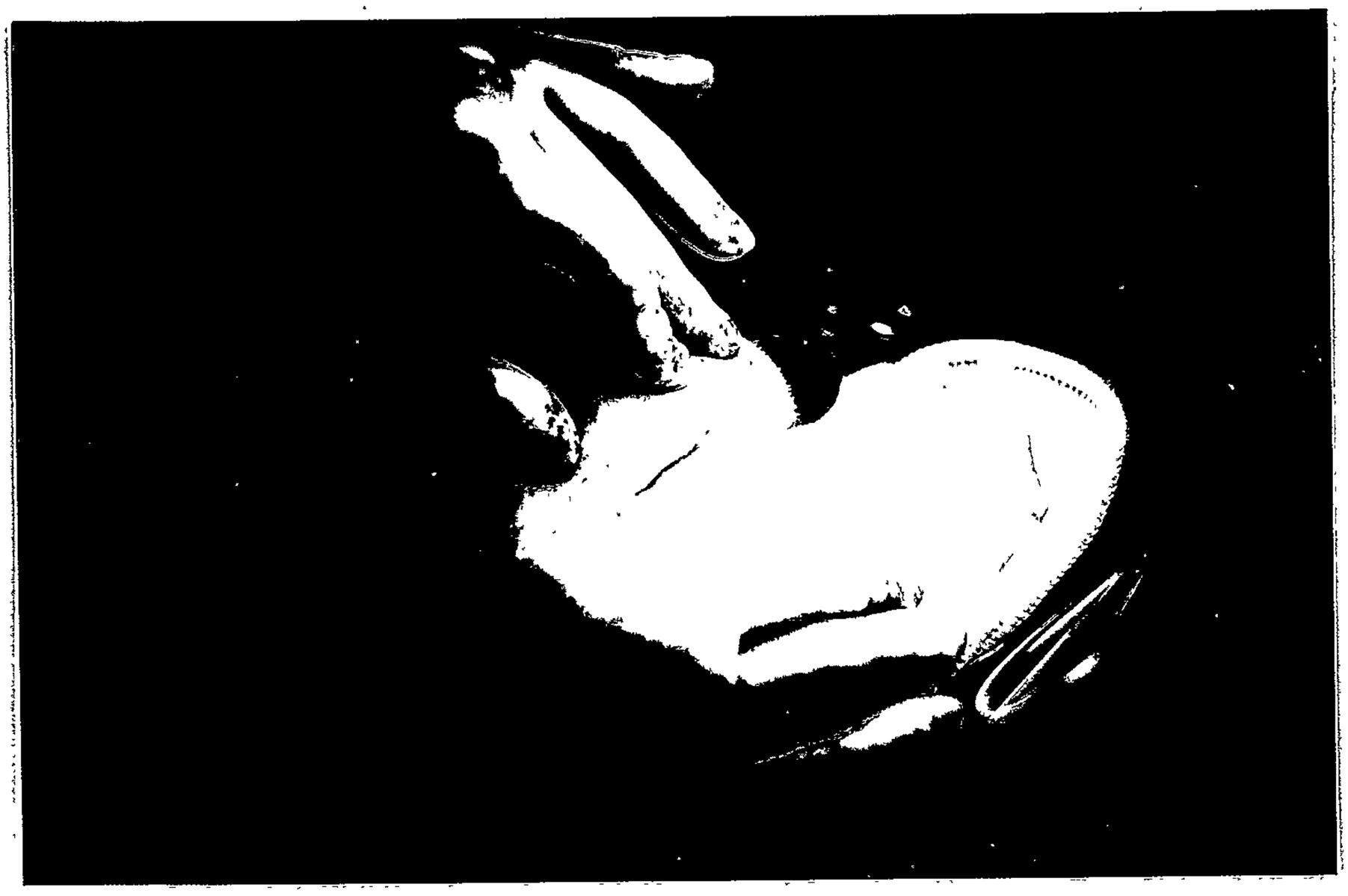
Dingman (Dingman 1948) performed the first step section on the body of the mandible for the correction of retrusion which also preserved the integrity of the neurovascular bundle. See **diagram 87.** The procedure could be performed with or without a graft depending on the severity of the retrusion. The procedure was virtually the same as that credited to Pehr Gadd in 1906 apart from the preservation of the mandibular bundle. Dingman had previously performed a similar procedure in 1944 (Dingman 1944c) for the correction of protrusion. This further emphasises that many procedures used for the correction of retrusion were first developed

Dingman's Step Body Osteotomy for Retrognathism.
From Dingman 1948.

Diagram 87

for the correction of protrusion and later adapted.

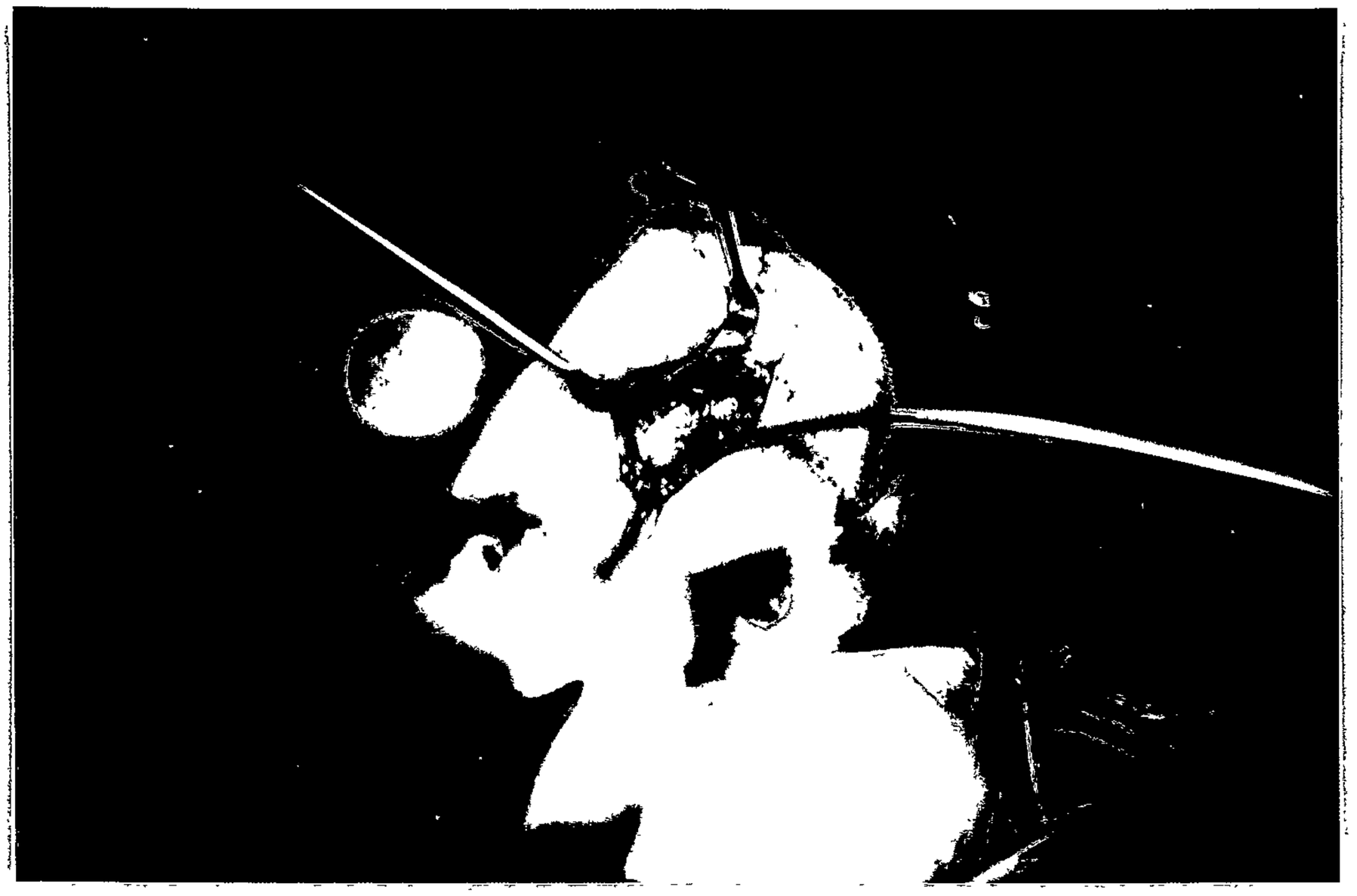
Dingman's procedure was a two stage procedure. The first stage, performed under a local anaesthetic, was a section approached through an oral incision which was vertical in the premolar region posterior to the mental foramen. The second stage, usually two to three weeks later, was through an extra-oral approach, (demonstrated in **Illustration 6**), under a general anaesthetic. A vertical lower border section was placed approximately two to three

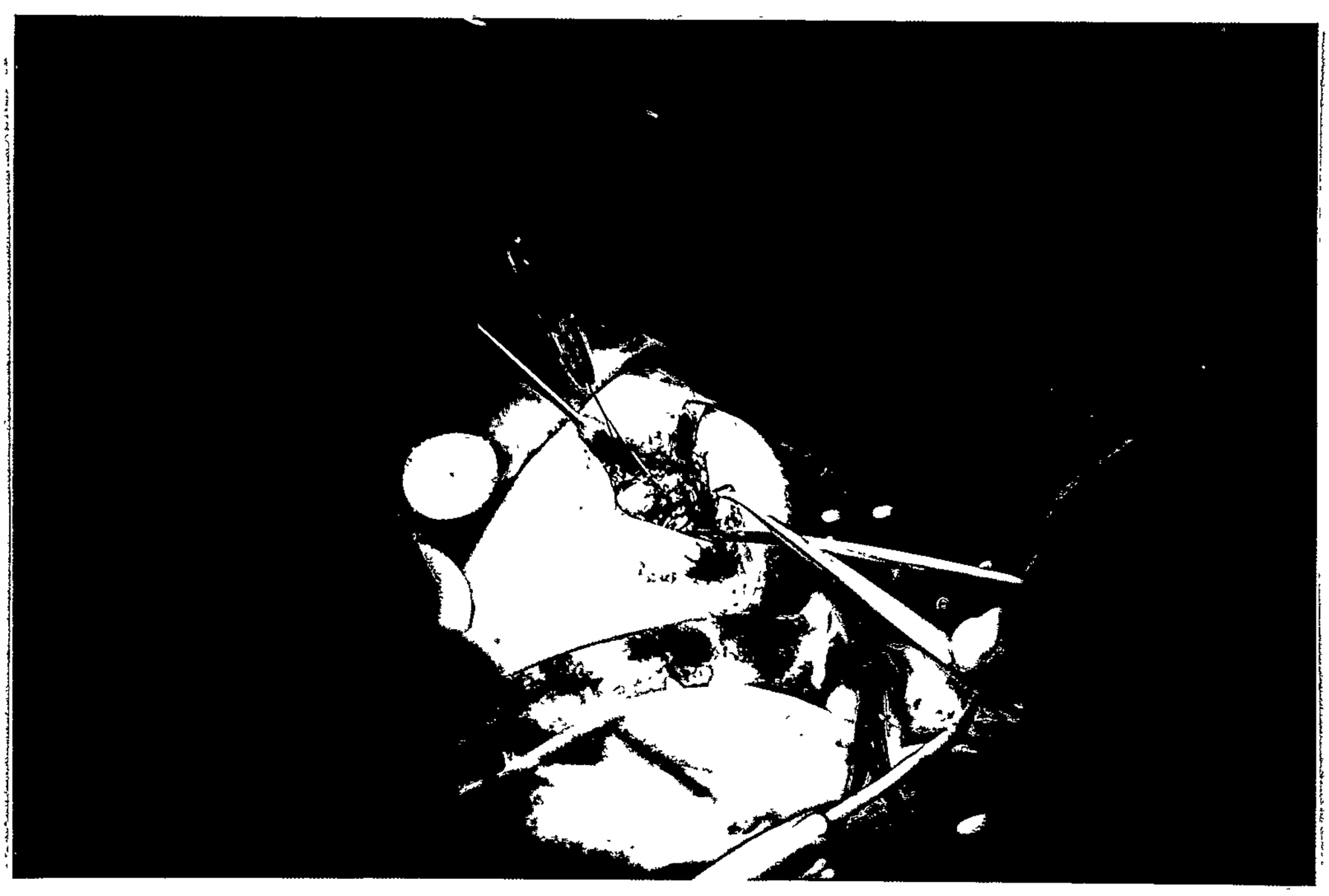


Extra-oral Approach to the Body of the

Mandible After Dingman

Illustration 6

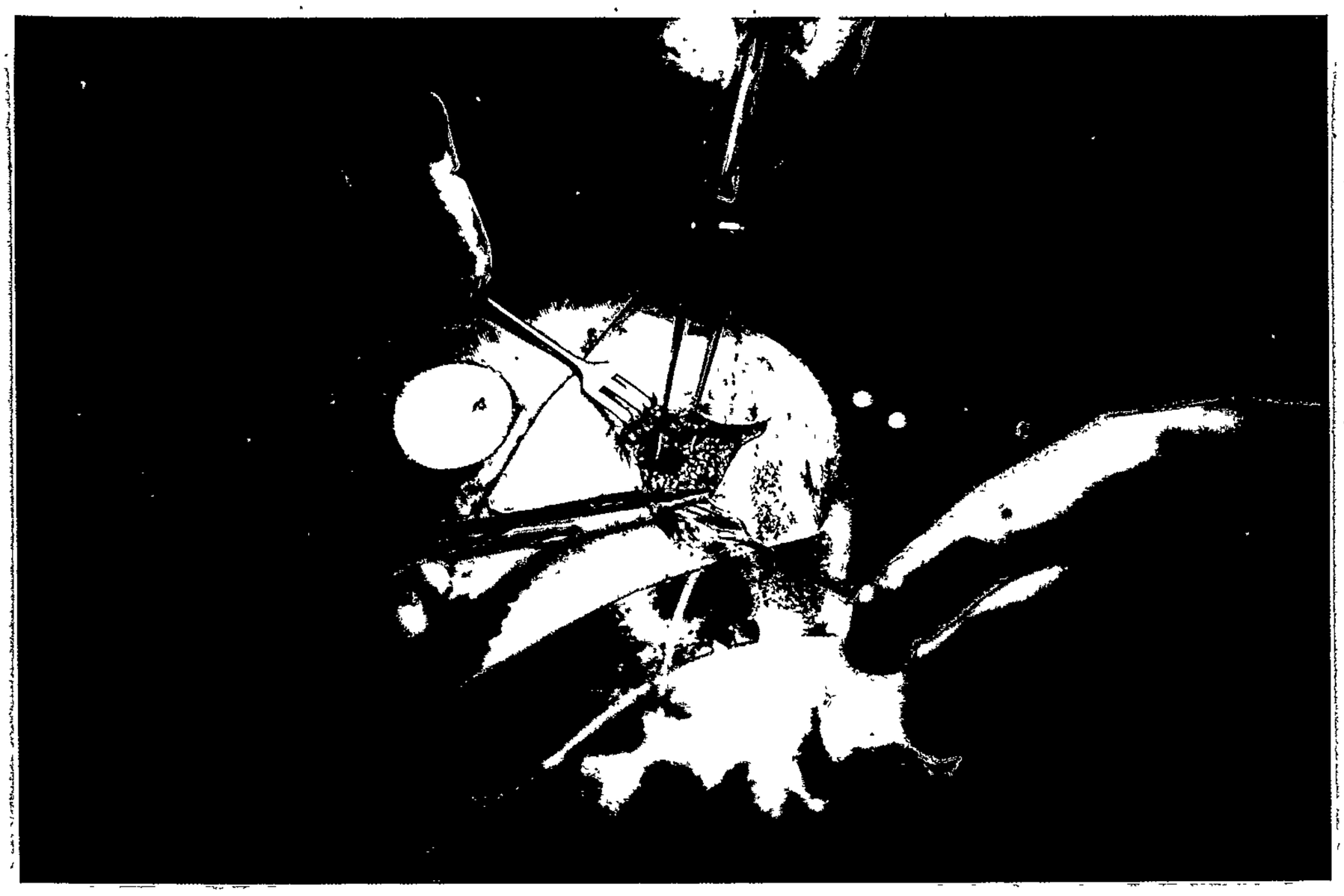




Extra-oral Approach to the Body of the

Mandible After Dingman

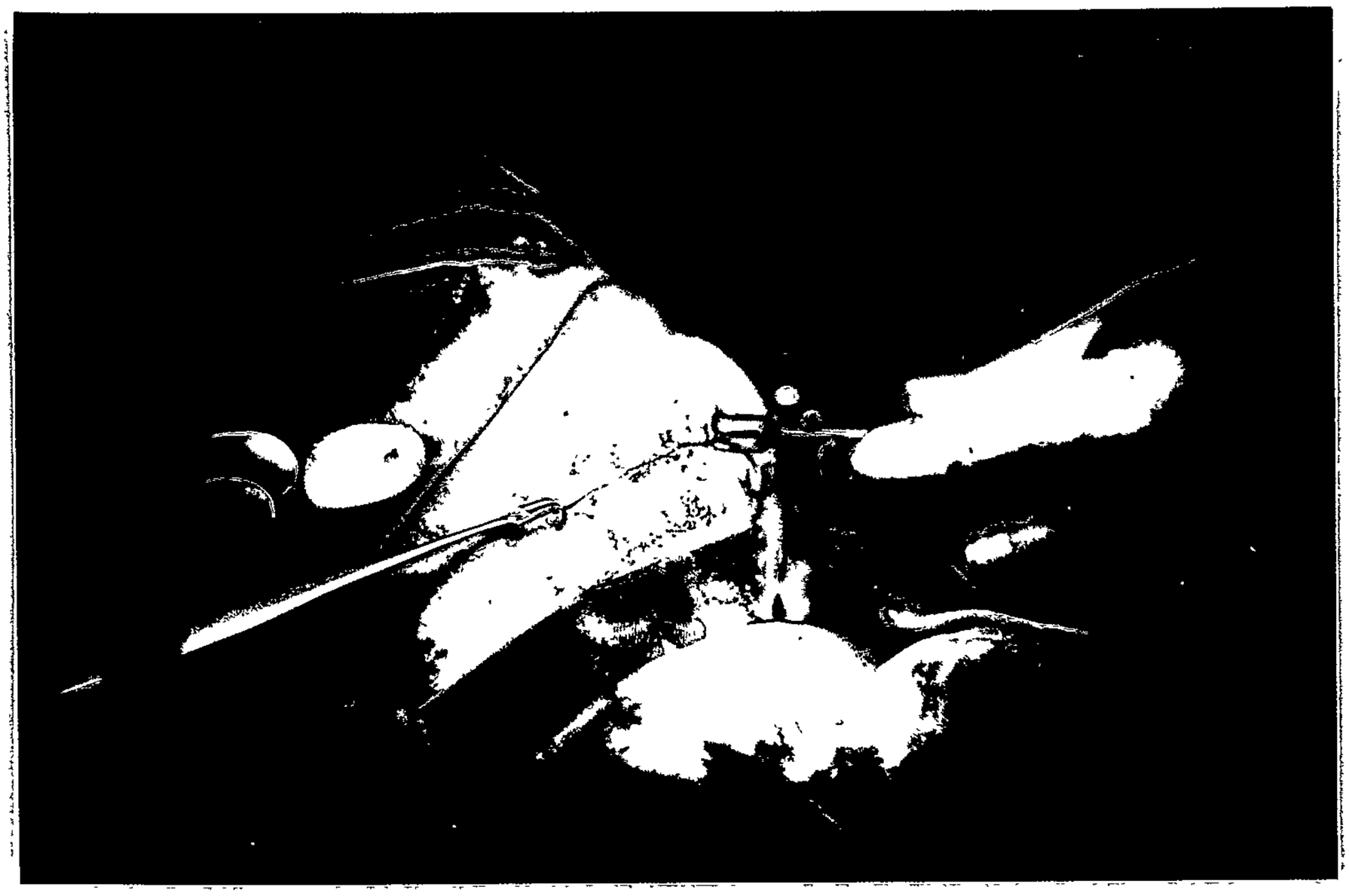
Illustration 6 Cont.



Extra-oral Approach to the Body of the

Mandible After Dingman

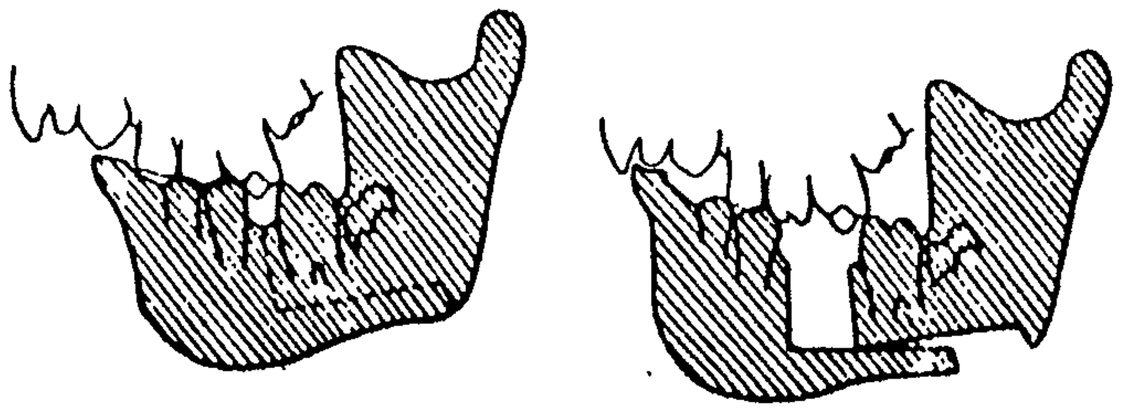
Illustration 6 Cont.



Extra-oral Approach to the Body of the

Mandible After Dingman

Illustration 6 Cont.



A. B.

Pichler & Trauner's Reverse Step Molar Body Osteotomy for the Correction of Retrognathism.
After Pichler & Trauner 1948.

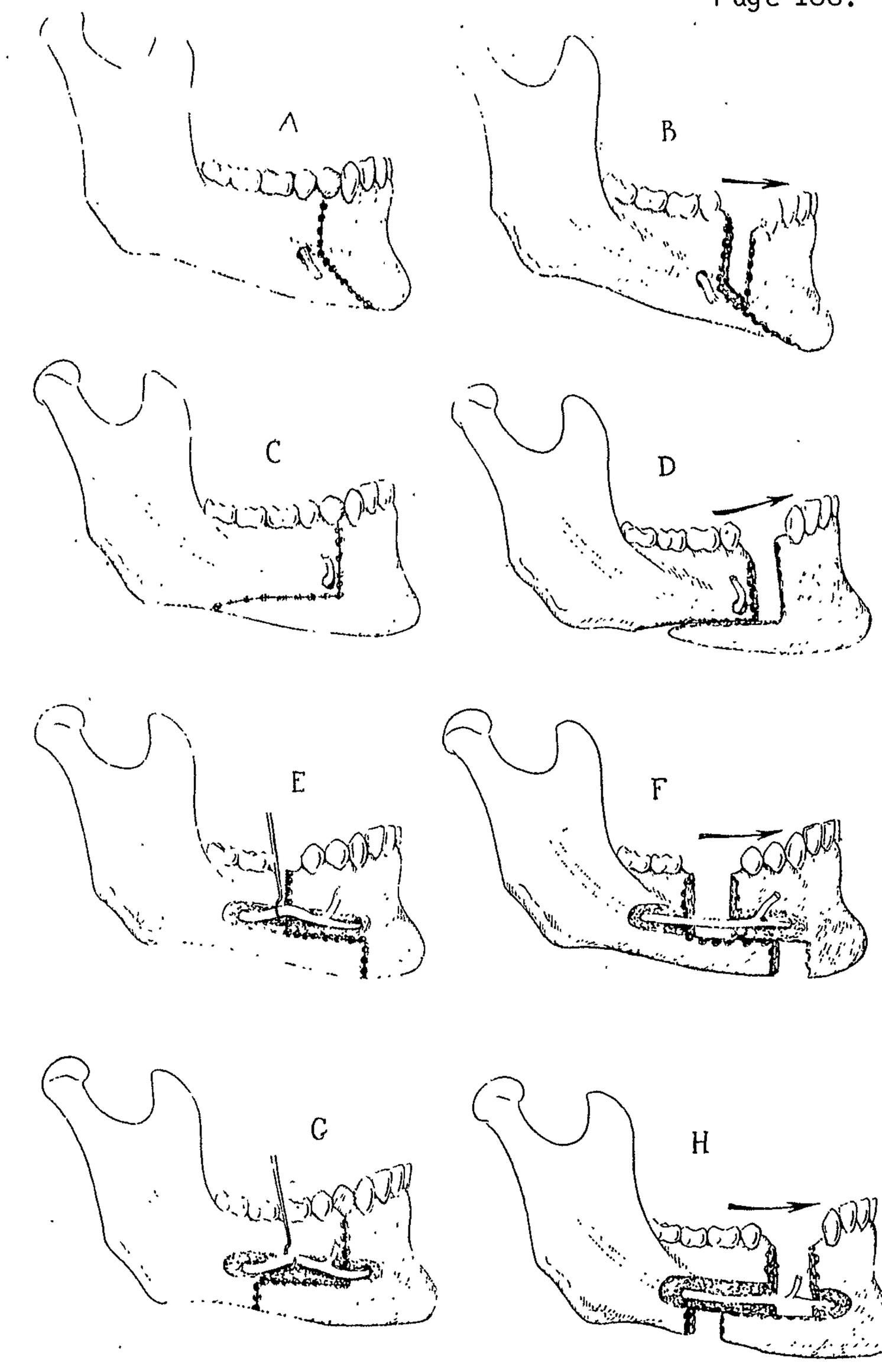
Diagram 88

centimetres anterior to the vertical cut placed in the first stage. The two cuts were joined up and the mandible fractured.

Pichler and Trauner (Pichler & Trauner 1948) reported a reverse step osteotomy that was based on Eiselsberg's (Eiselsberg 1906) step osteotomy of the body. See **diagram 88.** Trauner and Obwegeser (Trauner & Obwegeser 1957) noted that this procedure was suitable only for mild to moderate cases of retrognathism.

Converse (Converse & Shapiro 1952) performed the same procedure a few years later but made the procedure a single stage operation with the entire procedure performed through an oral approach.

In 1955, Fickling and Fordyce (Fickling and Fordyce 1955) reported the same procedure using iliac crest chips to fill in the spaces, and later Armbrecht et al. (Armbrecht, Clarke & Kline

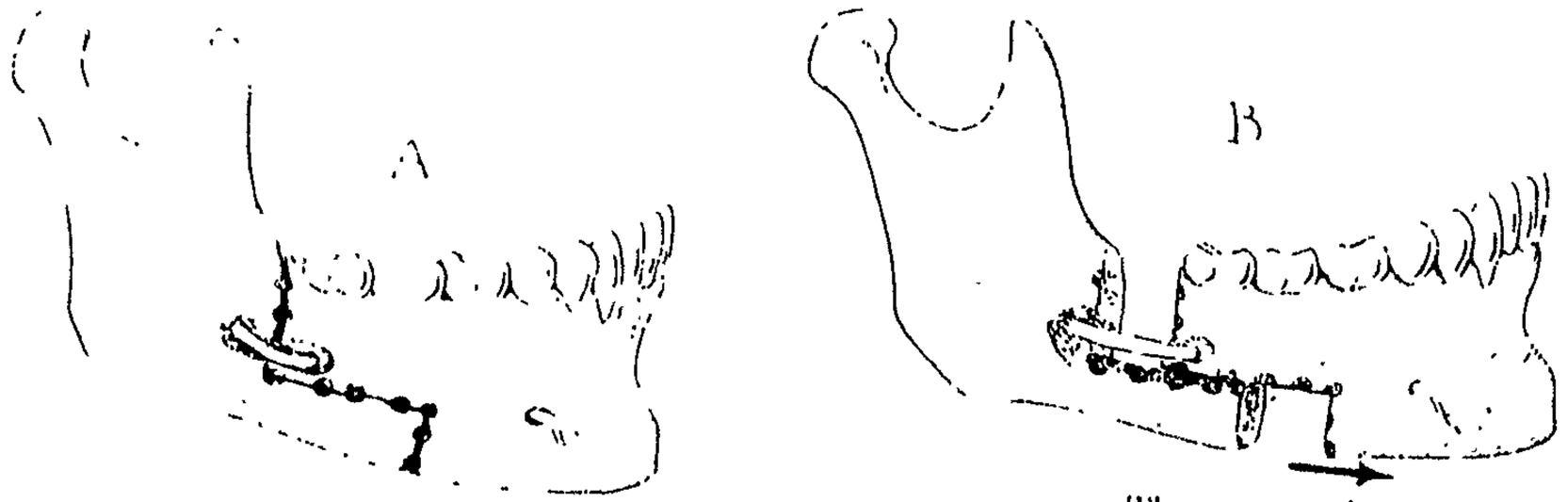


Four types of osteotomy of the mandible. *A*, The L osteotomy anterior to the mental foramen. *B*, Elongation gained by L osteotomy. *C*, The reverse L osteotomy, a favored technique for elongation of the body of the mandible. *D*, Elongation obtained by the reversed L osteotomy.

E, Step osteotomy posterior to the mental foramen, with exposure of the inferior alveolar neurovascular bundle. *F*, Elongation following step osteotomy. *G*, Reverse step osteotomy anterior to the mental foramen showing exposure and preservation of the anterior-inferior alveolar nerve. *H*, Elongation following reverse step osteotomy. (From Kazanjian and Converse: The Surgical Treatment of Facial Injuries, Williams & Wilkins Co.)

Range of Step Osteotomies of the Body for the Correction of Retrognathism.

Diagram 89



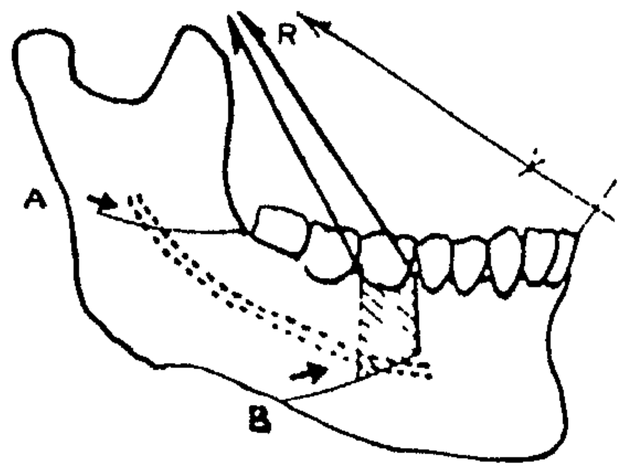
The retromolar step osteotomy for elongation of the body of the mandible.

Range of Step Osteotomies of the Body for the Correction of Retrognathism. (Cont.)
From Converse 1968.

Diagram 89

1957) used the resected bony fragments as well as iliac crest graft to provide chips to fill in the bone spaces. The latter authors were also the first to report the use of a reciprocating saw to section the bone. It was not until over twenty years later that Fordyce (Fordyce & Wedgwood 1976) showed that (even finer) bone mush taken from just under the iliac crest and placed around the osteotomy site produced even faster healing times than bone chips. There was also the advantage that the shape of the iliac crest was left essentially intact.

Converse et al. (Converse, Horowitz and Wood-Smith 1968) in their textbook on Plastic Reconstructive Surgery showed a variety of body procedures that could be used for the correction of retrognathism. See **diagram 89.** Variations shown were the step and reverse step body osteotomies with the vertical section anterior or posterior to the Mental Foramen. Also shown was a retromolar step

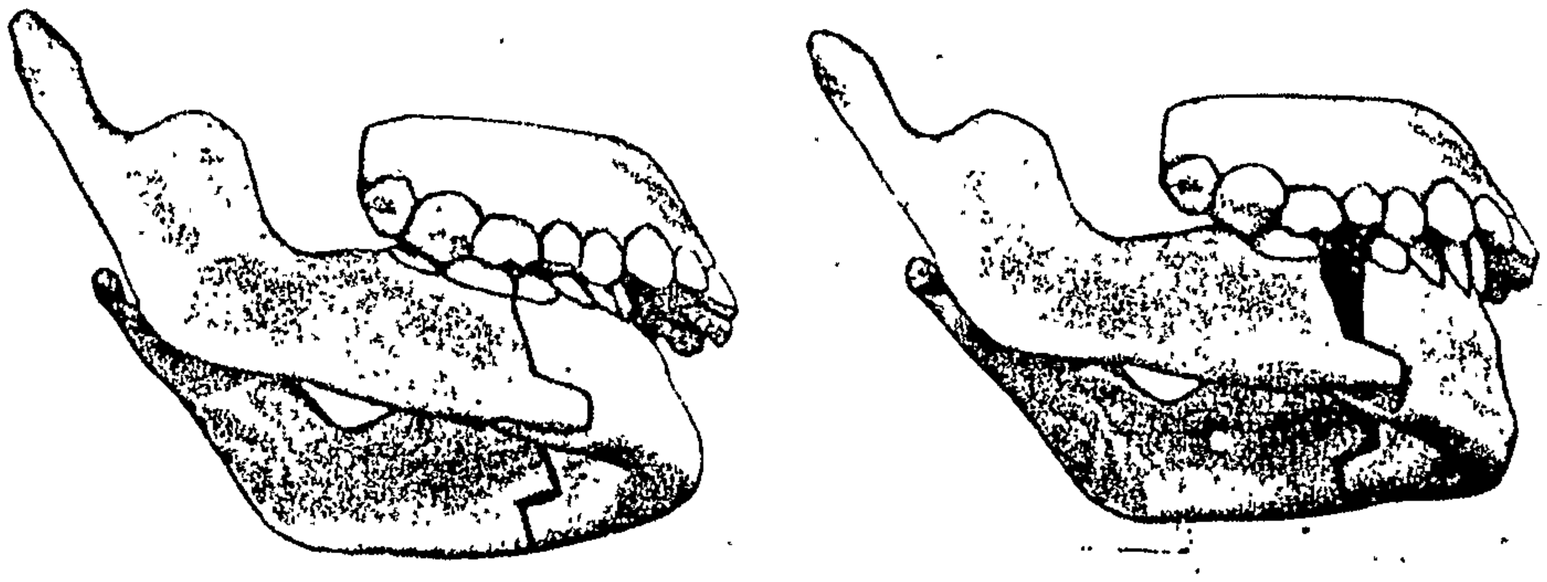


Trauner's Biangled Wedge Osteotomy for the Correction of Open Bite and Retrognathism. From Trauner 1969.

Diagram 90

osteotomy which Converse recommended where conservation of tooth structure was required, and also showed the "L" and reverse "L" body osteotomy again with the vertical section anterior or posterior to the Mental Foramen. Most of these procedures were attributed to himself (Converse 1964) and Kazanjian from a previous textbook (Kazanjian & Converse 1959), but which Limberg (Limberg 1926, 1928) and Hensel (Hensel 1937) attributed to Eiselsberg and Pehr Gadd. In fairness Converse did in general acknowledge the role of Eiselsberg for the technique of the step osteotomy of the mandible.

Trauner (Trauner 1969) recommended a bi-angled body section with the degree of the angles proportional to the amount of the correction required, for the correction of retrognathism where there was a simultaneous open bite present. See **diagram 90.** The cuts are the same as described by Trauner in the same article for the correction of prognathism, but the cuts are in reverse. Again the section cuts are similar to those described by Eiselsberg and Pichler in 1912, but the section cuts are not parallel as Eiselsberg and Pichler's are. (See section Apertognathia).



Mehnert's Variation of Sada's Procedure
Used for the Correction of Retrognathism
in Dentate Mandibles.
From Mehnert 1972.

Diagram 91

Mehnert (Mehnert 1972) described a variation of Sada's sagittal split body osteotomy. Where Sada described his procedure for the correction of prognathism in edentulous mandibles, Mehnert designed his procedure for the dentate mandible. The procedure could be used for either the correction of retrognathism (see **diagram 91** or the correction of prognathism as previously described in the section on Prognathism.

Sandor et al (Sandor, Stoelinga & Tideman 1982) in a review of the step body osteotomy, recommended the use of the step body osteotomy for the correction of retrognathism. Sandor advised the use of a bone graft to fill the bony gaps as well as noting that extractions are not necessary to perform the surgery. With the fine chisels that are available the non-extraction of teeth should not be problem in most cases where there are no edentulous spaces to make

use of. Furthermore the use of fixed bridgework or removable partial dentures post-operatively provides further stability. The advantages and disadvantages of the step body procedures have been discussed in the chapter on body procedures for the correction of prognathism, and essentially are applicable in the treatment of retrognathism.

Summary.

While possibly undergoing a return to favour, the use of body procedures for the correction of retrognathism still has basic problems that will probably not allow body procedures to assume a dominance in the literature the way ramus procedures do. Problems such as:

1. Poor, weak or non-union at the osteotomy site.
2. Paraesthesia or anaesthesia of the Mandibular nerve. As has been seen, direct access and consequent preservation of the neurovascular bundle has not been an assurance of preservation of normal function of the nerve.
3. Muscle pull from the suprahyoids leading to relapse or open bite or both.
4. There is usually a need for a graft to make up for the deficient bone.
5. The general difficulty with obtaining good fixation.
6. The lack of sufficient soft tissue mobility to cover any bony gap created by the extension of the body of the mandible.
7. Where there have been teeth removed, or the section has taken place in the tooth bearing areas, there is need for a subsequent prosthesis.
8. If there is a deficiency at the gonial angle, body procedures cannot correct the problem.

These are problems related to body procedures in general. There have

been specific problems related to particular procedures such as the Retromolar osteotomy, which suffers from the disadvantage of being difficult to do (Converse & Shapiro 1952) and not for general use but for specific indications.

Nonetheless there are advantages to the use of body procedures that indicate their use in specific cases where the use of ramus procedures would not be advantageous. Advantages such as:

1. There is no change to the gonial angle, where the gonial angle is normal, when the correct body procedure is chosen.
2. There is no change to the posterior occlusion, where this is normal, when the correct body procedure is chosen.
3. Lingual tilting of the occlusion can be corrected by suitable tilting of the fragment(s), something the ramus or whole body procedures cannot do.

Body procedures do have a specific place in the general range of procedures for the correction of mandibular retrognathism and will give satisfactory results provided that the procedure is "custom tailored" to the deformity and not the patient "fitted" to the procedure.

General indications for body procedures for the correction of retrognathism would be:

1. Normal gonial angle.
2. Normal posterior occlusion.
3. The deformity not amenable to ramus or other procedure.

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MANDIBULAR LATERAL DEFORMITIES

Lateral Expansion and Contraction Procedures

Introduction.

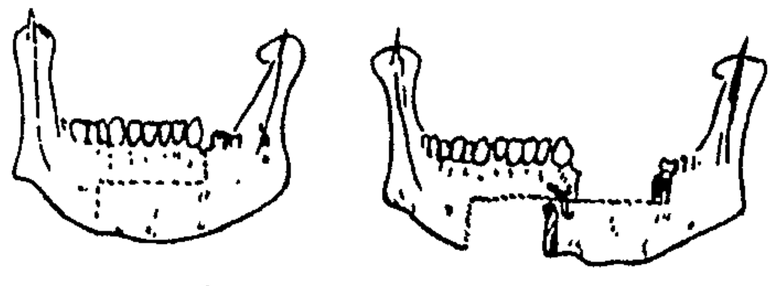
Lateral expansion and contraction of the arch is not a commonly reported procedure. The problem may lie in the procedure, having possible inherent healing problems. Converse (Converse & Horowitz 1973) reported a case of "Simianism" where the mandible in particular but also the maxilla, showed elongation and narrowing. Converse chose to treat the problem with a body procedure to retrude the mandible and correct the prognathism rather than correct the narrowing as well.

Unless step like section cuts are made, healing can be a problem. The increased area from providing a step section cut greatly increased the chances of a good union.

Discussion.

Eiselsberg (Eiselsberg 1906) was the first to report the use of the symphysis for the expansion of the mandibular arch. Eiselsberg's method of mandibular arch expansion was a step osteotomy at the symphysis to gain an expansion of the mandibular arch to correct what was a mandibular crossbite with normal mandibular anterior-posterior dimension. See **diagram 92.**

Sowray and Haskell reported doing a procedure at the symphysis for the contraction of the arch for a case of severe crossbite of the mandible as well as moderate prognathism of the mandible. These two surgeons decided to treat the problem with a



-Osteotomy (Eiselsberg method).

Eiselsberg's Symphysis Expansion Step Osteotomy.
From Limberg 1928.

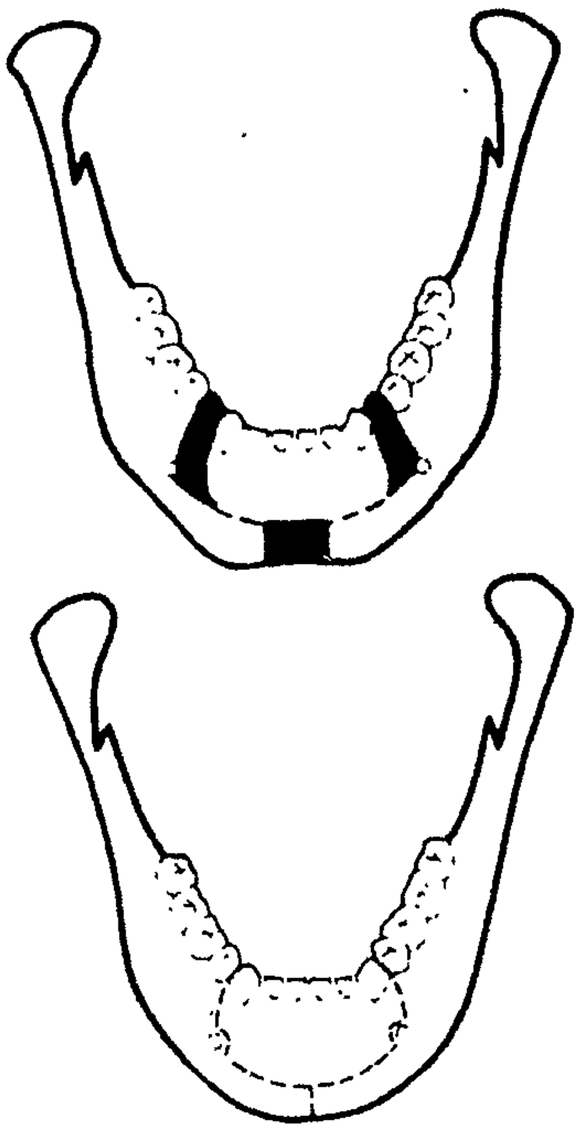
Diagram 92

contraction of the mandibular arch at the symphysis combined with a setback of anterior alveolar segment. (Sowray & Haskell 1968). See **diagram 93.**

Using a degloving procedure, (demonstrated in **Illustration 7** for correction of a deficient arch/symphysis), the symphysis was exposed from second molar to second molar. A segment of bone was mobilised that contained the anterior six teeth. The section cut was below the apices of the teeth and included the genial tubercles in the fragment due to the large blood supply from the attached muscles. The vertical cuts for this segment were made in the first premolar region with just sufficient lingual periosteum raised to place a protective retractor. The first premolars had been removed previously under local anaesthetic. The mental nerve was avoided and thus kept intact. As much bone as possible was removed from the premolar regions to allow retrusion of the anterior segment. Another vertical cut was placed in the symphysis midline and enough bone resected to allow adequate collapse of the posterior segments bilaterally to correct the crossbite. Approximately

Symphysis Degloving After Obwegeser

Illustration 7



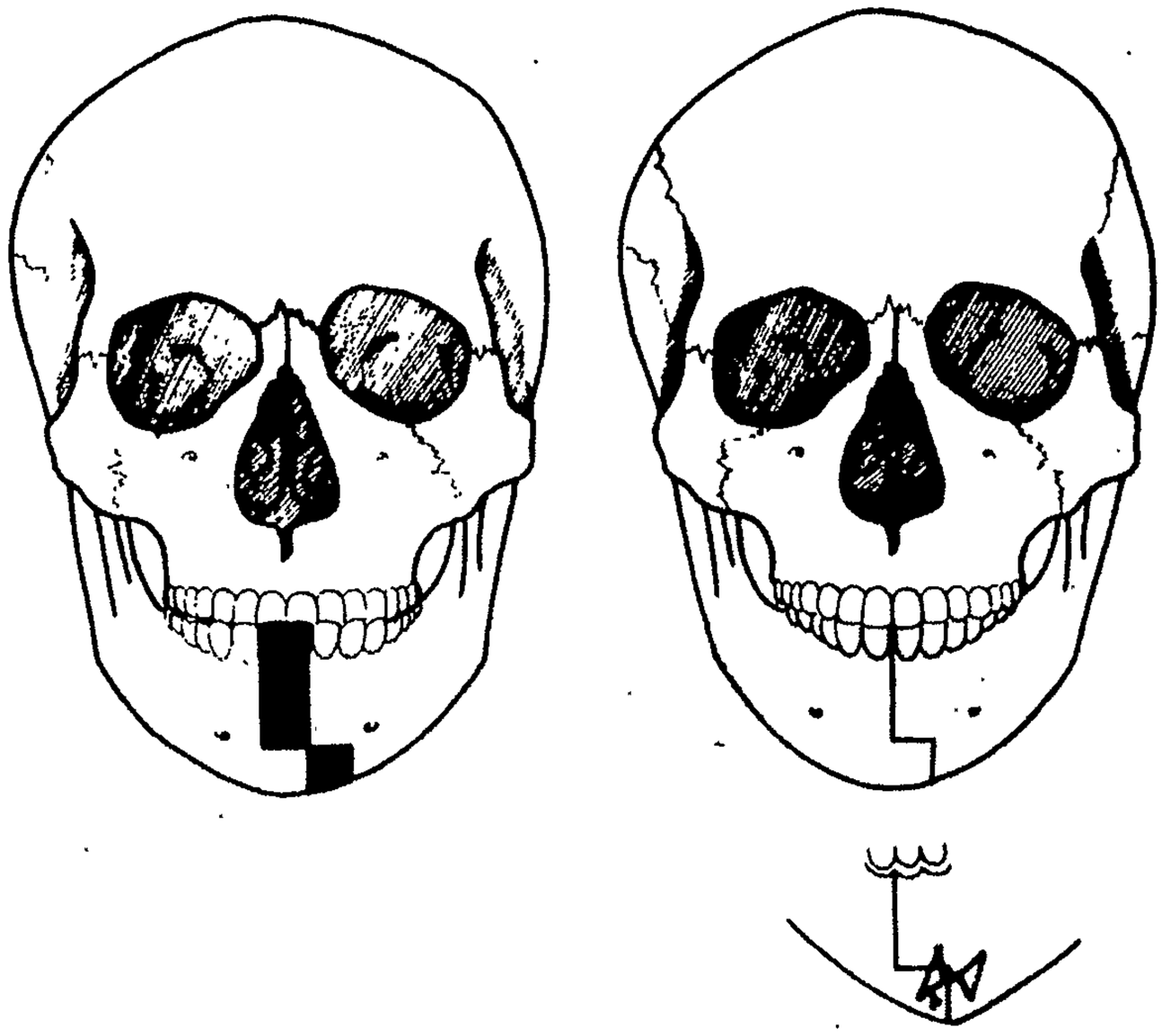
Diagrams showing by means of shading the sites of bone and tooth removal. The posterior fragments rotate medially and the anterior fragment moved posteriorly.

Sowray & Haskell's Symphysis Contraction Osteotomy.
From Sowray & Haskell 1968.

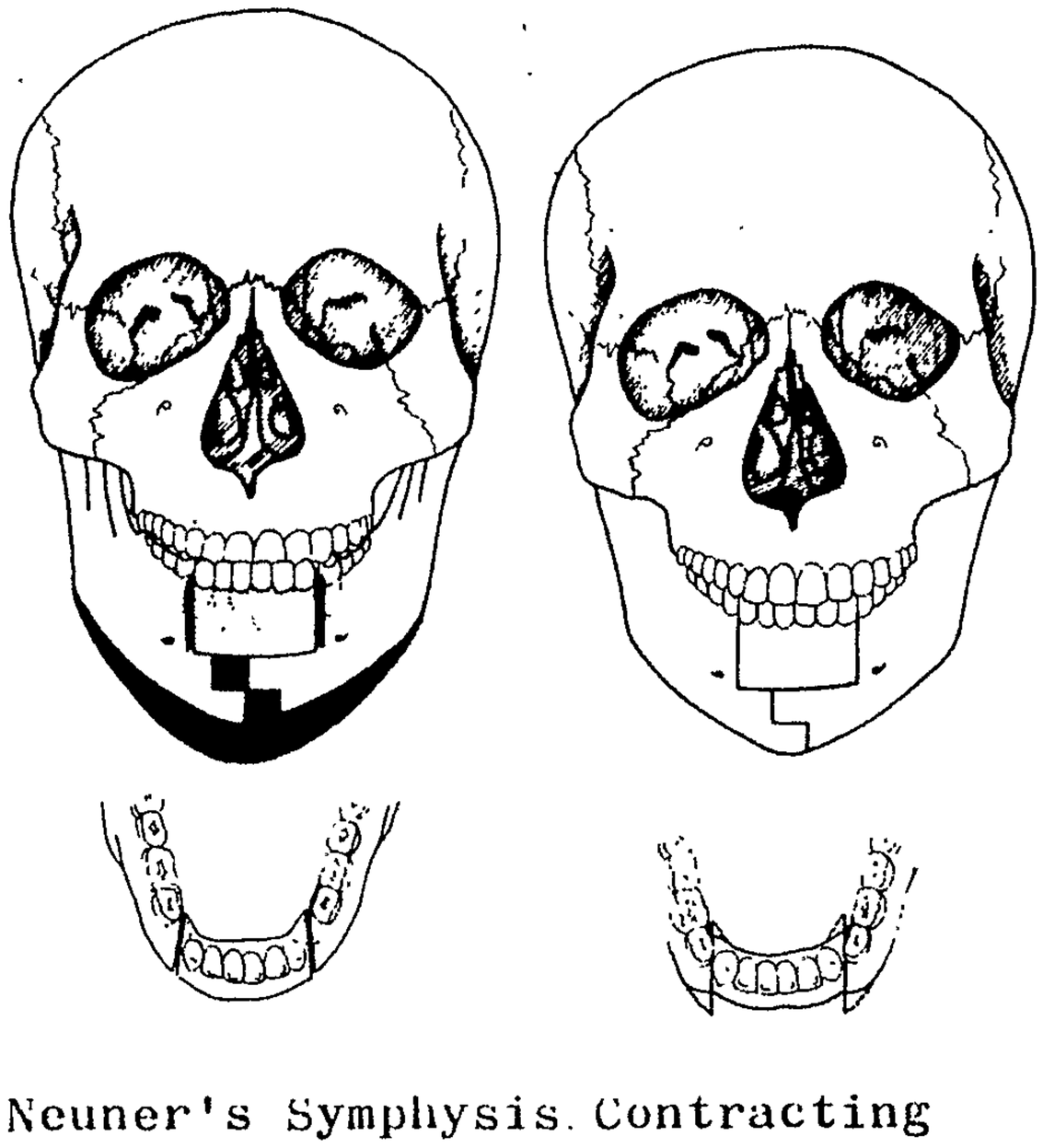
Diagram 93

fourteen millimetres of bone was removed from the premolar sites (each side) and slightly less from the symphysis. See **diagram 93.** (Sowray & Haskell 1968).

The two posterior fragments were reduced and fixed in the midline with interosseous wiring with bone chips placed in the gaps. A three-part cap splint was cemented with the parts immobilised with inter-splint wiring. The authors commented that circumferential wiring should have been used at the same time to further secure the cap splints as one came loose some days after cementation. (Sowray & Haskell 1968).



Neuner's Symphysis Contracting Osteotomy I.
From Neuner 1976.



Neuner's Symphysis Contracting
Osteotomy II.
From Neuner 1976.

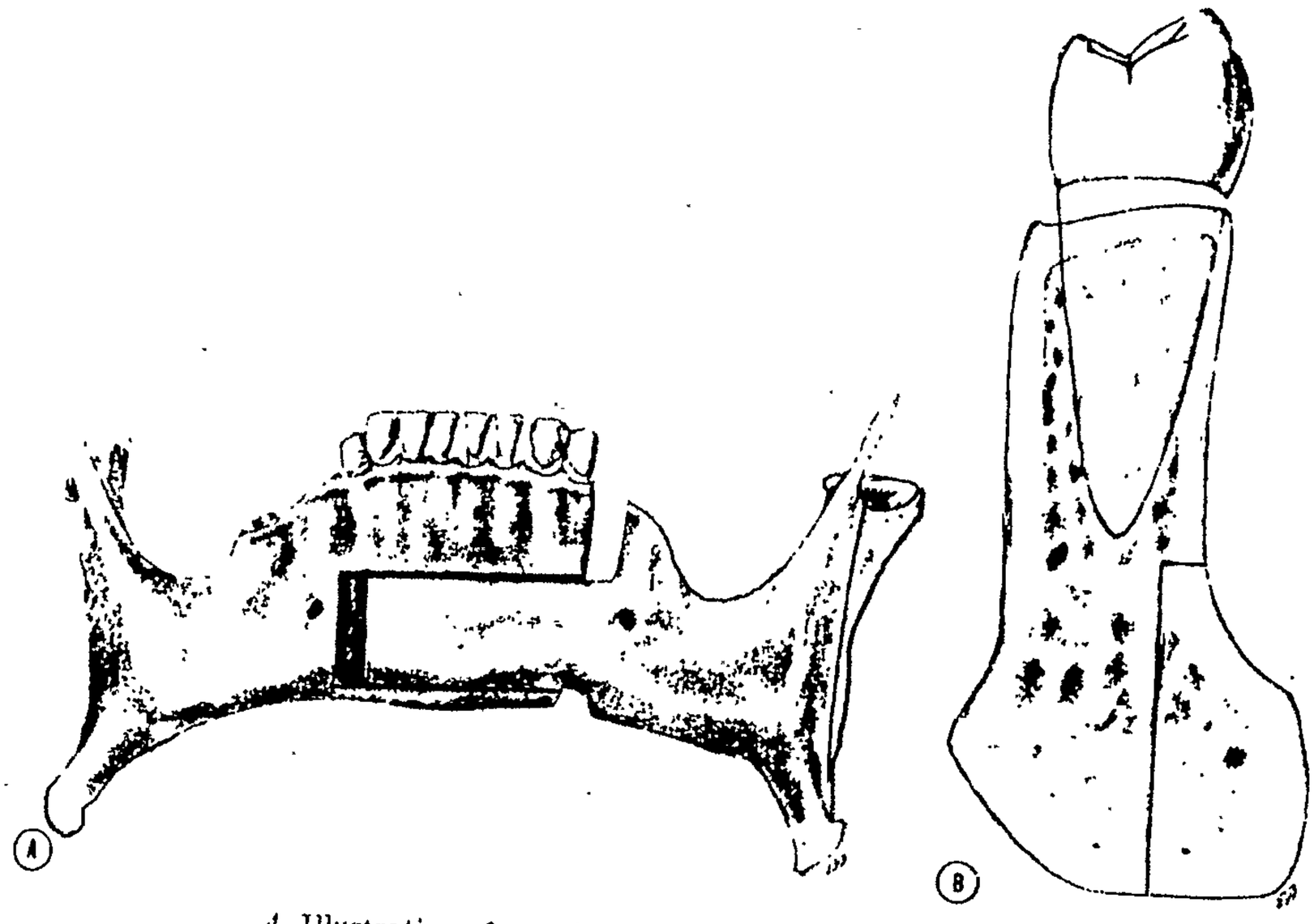
Diagrams 94 & 95

The authors commented that the patient had no distress related to the rotation of the condyles, and that union and stability at three and a half months was good. Also there was a positive response to electric pulp testing. (Sowray & Haskell 1968).

Neuner (Neuner 1976) reported a series of symphyseal procedures. One procedure was an identical procedure as reported by Eiselsberg except the mandibular arch was contracted to correct a crossbite deformity. See **diagram 94.** A second procedure was an attempt to correct a combined crossbite and mild prognathism of the mandible, the same problem that Sowray and Haskell treated, except the body section at the symphysis was a step osteotomy very similar to Eiselsberg's procedure, combined with the anterior subapical procedure that Sowray and Haskell employed. See **diagram 95.** Fixation in both cases was by acrylic wafer splint and interosseous wiring.

In 1977 two surgeons reported a new symphyseal technique that was a modification of a first technique, also new. Both procedures were called sagittal symphysotomies. The surgeons were Super and Guernsey (Super & Guernsey 1977). The modified procedure involved the full width of the mandible and will be discussed under body procedures. The first technique is not a full width procedure and will be discussed under the chapter on Symphyseal procedures.

The modified procedure made use of a vertical section of the body on the lingual side of the body in the region of the canine/first premolar. On the buccal side a vertical section was commenced and then followed by a horizontal section approximately



A, Illustration of symphysotomy

B, Sagittal view of cuts.

Super & Guernsey's Modified Sagittal Symphysotomy.
From Super & Guernsey 1977.

Diagram 96

three millimetres below the level of the apices of the teeth. The horizontal section was continued until the canine/first premolar region of the opposite side. The section then proceeded to the lower border producing a step section on the lateral aspect of the body. From the lower border the section proceeded along the lower border sagitally to meet with the lingual vertical section. By means of fine chisels and osteotomes the step was sectioned away from the body. See **diagram 96.** The body of the mandible may be widened (as was performed in the report) or made narrower according to the desired position of the occlusion and the mandible.

The report considered two main advantages of this procedure:

1. Elimination of alloplastic or autogenous grafting to the surgical site.

2. Provision of maximum bone contact for early stabilisation and healing.

and the following disadvantage:

1. The increased difficulty of this procedure compared to the horizontal body osteotomy.

Summary.

The procedures would be generally indicated where there is a narrowing or expansion of one arch and not of the other. Thus producing either a crossbite or reverse crossbite. The crossbite indication would be based on the skeletal bone and thus a skeletal discrepancy and not a dental one. Dental crossbites whether total arch or segmental would be best corrected by orthodontic treatment or with the use of subapical procedures, segmental or total depending on the nature and degree of the crossbite.

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APERTOGNATHIA (OPEN BITE DEFORMITY)

Introduction.

It is important to differentiate between the two types of open bite. Firstly non-skeletal open bite, sometimes called anterior open bite, is characterised by a non-flat, distinctly curved mandibular occlusal plane, with antegonial notching, normal gonial angle and the open bite occuring on the anterior teeth only, the curve usually commencing on the premolars or the canine teeth.

There is a subdivision of non-skeletal open bite which is uncommonly seen and even less so treated by the surgeon. This is the lateral open bite. Essentially non-skeletal in nature it can show skeletal (body) characteristics in the severe case (see below). The deformity is principally dental in nature and not skeletal, with the deformity present mainly in the premolar region and occasionally the molar region. The open bite can be unilateral or bilateral. The deformity tends to be associated with a mouth habit.

Secondly there is skeletal open bite, where the mandibular occlusal plane is relatively flat, the gonial angle is usually obtuse and there is no or very minimal antegonial notching. The open bite usually occurs on the last standing molar tooth, but certainly is in the molar region (presuming there are standing molar teeth.).

As well there is a skeletal open bite subdivision called posterior open bite or lateral (skeletal) open bite. The open bite deformity is present in the posterior segment of the occlusion

either unilaterally or bilaterally, with the anterior segment in good position. The deformity is present in either the molar or premolar region (usually the former) and is severe compared to the non-skeletal lateral open bite. The gonial angle is usually but not always obtuse, and there is nearly always the reverse of antegonial notching; an antegonial "bump". The occlusal plane is exaggerated. This deformity is nearly always associated with a deformity of the maxilla which also has a marked non-level occlusal plane.

The treatment for each differs. Basically treatment of the non-skeletal open bite, usually anterior but also lateral except in the severe case, requires the procedure to be limited to the body of the mandible whether the procedure is a full body procedure or a subapical procedure. Treatment of the skeletal open bite requires resetting the whole of the arch with the main aim of correcting the angle of the mandible. Such procedures are usually ramus, angle or retromolar procedures, or a combination.

As the commonest type of open bite deformity is the anterior open bite, this was the problem that was first tackled, and mostly reported on.

Discussion.

Body procedures were the first to be developed for the correction of open bites in general and anterior open bites in particular. This chapter will be divided into two parts. Firstly anterior or non-skeletal open bites as these were historically the first to be corrected, and secondly posterior or skeletal open bites.

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APERTOGNATHIA (OPEN BITE DEFORMITY)

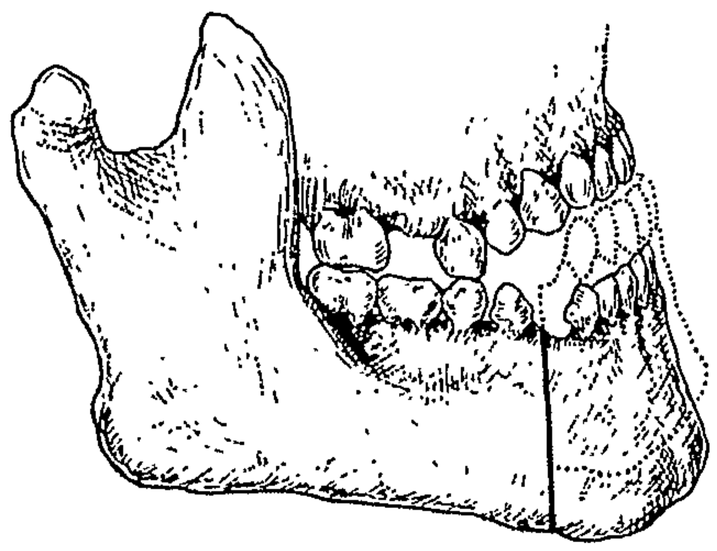
Non-skeletal Open Bite.

Body Procedures.

Hullihen was the first to correct open bite deformity using a subapical type procedure which will be discussed later. However it was Lane (Lane 1906) and subsequently Blair (Blair 1907) and Pickerill (Pickerill 1912) who were the first to perform full thickness osteotomy cuts of the mandible in order to correct anterior open bite deformity, using an extra-oral approach. See **diagram 97.** The vertical section extended into and through the mandibular base bone. All surgeons performed the procedure in the premolar region. The facial height was able to be shortened, which Hullihen could not do with his procedure. The neurovascular bundle was severed with no attempt at preservation.

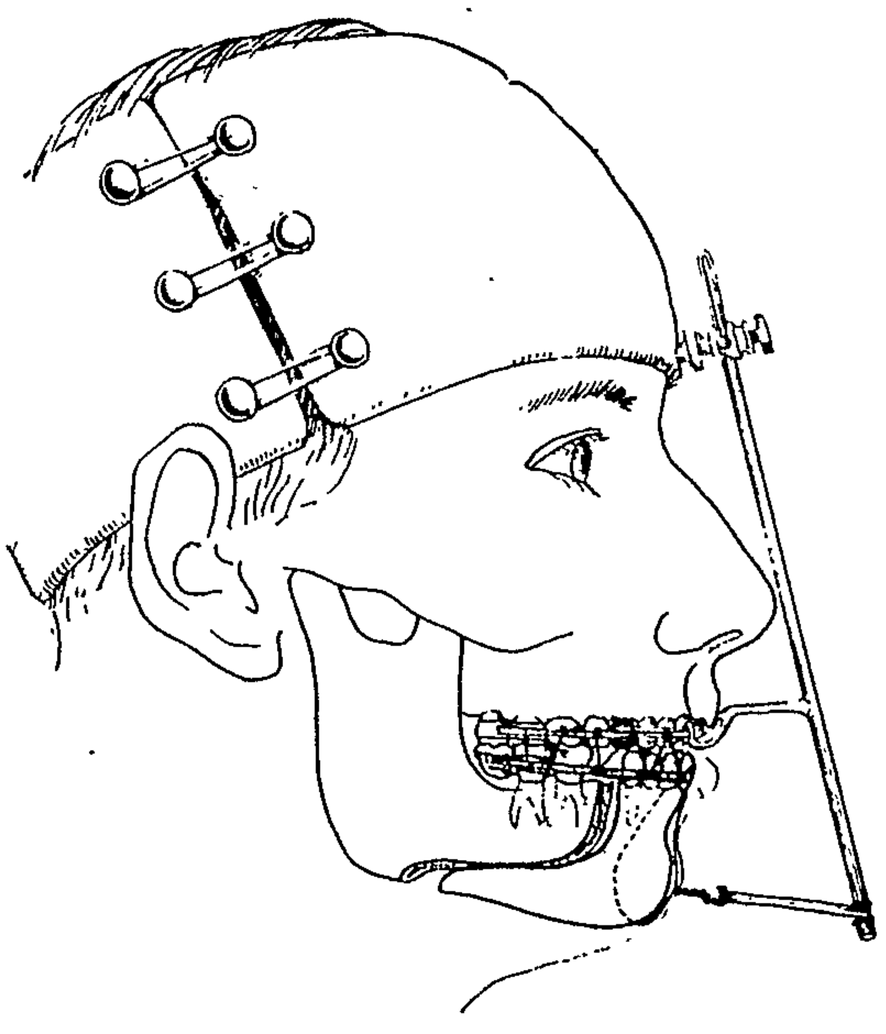
Aller (Aller 1917) used a "V" shaped premolar wedge cut for anterior open bite deformity as well as prognathism correction. The approach was via an oral incision. Bruhn (Bruhn 1927) tried a basically orthopaedic approach when he sectioned the mandible vertically in the premolar - canine region, and subsequently applied traction to the anterior fragment to close the open bite, both skeletal and non-skeletal. The appliance was a head cap with an extension similar to a halo extension for the treatment of mid-third facial fractures and a traction attachment to the anterior mandibular fragment. While the traction appliance was cumbersome, the result was quite satisfactory although no long term follow-up was performed.

Kazanjian and Converse (Kazanjian & Converse 1959.)



Blair's Full Thickness Body Section
for the Correction of Apertognathia.
From Blair 1907.

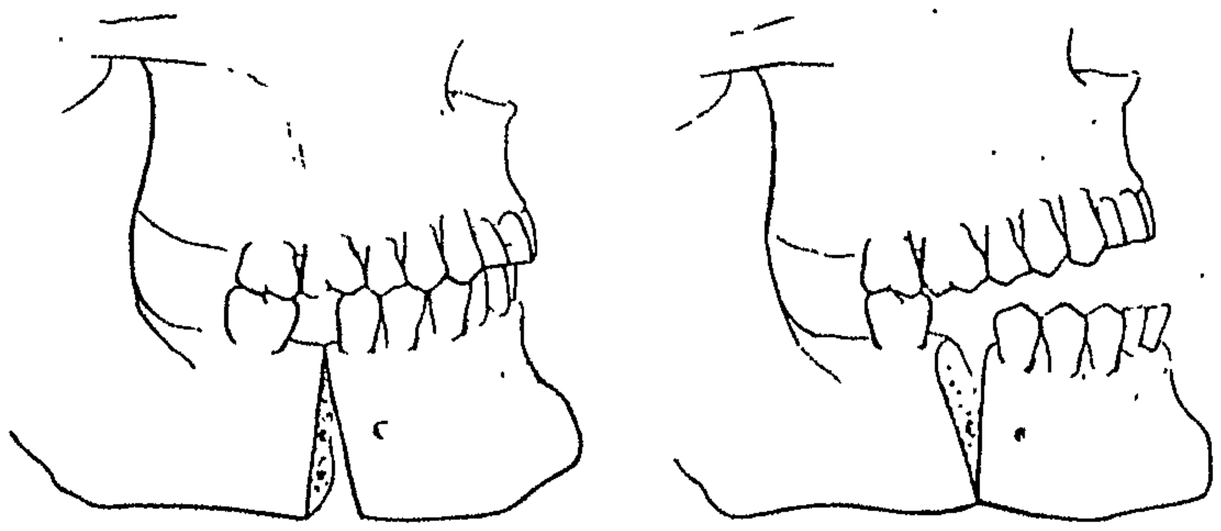
Diagram 97



Combined extraoral and intraoral splint with elastic traction to a circumferential wire from the lower end of the vertical bar to prevent the posterior and inferior pull on the symphysis of the mandible. (From Kazanjian and Converse: The Surgical Treatment of Facial Injuries, Williams & Wilkins Co.)

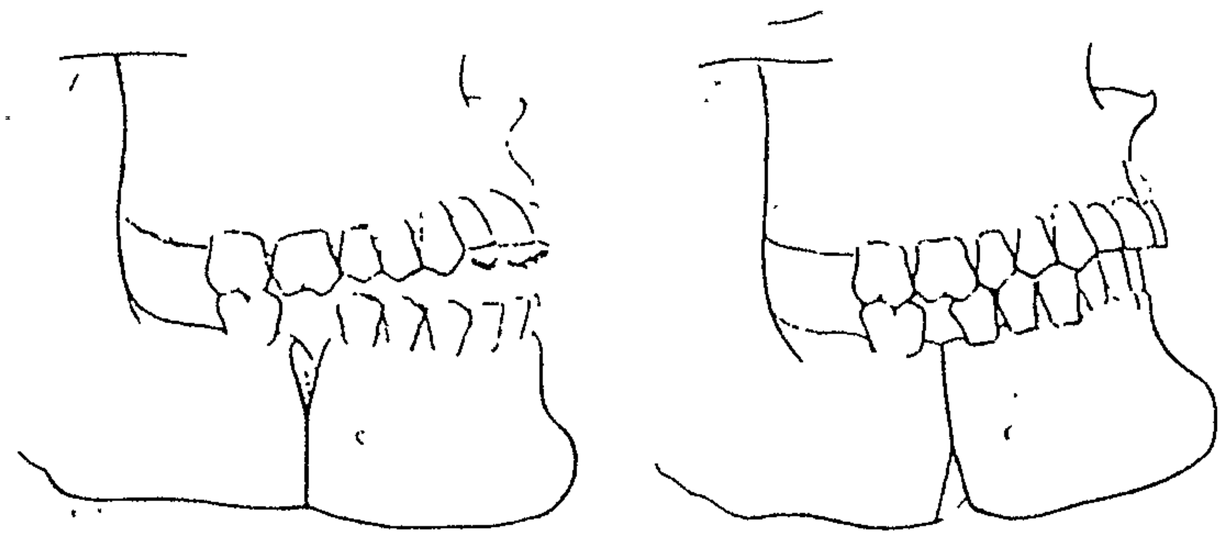
From Kazanjian & Converse
1959.

Diagram 98



left. Simple bilateral osteotomy causes V-shaped space to open when the anterior fragment is placed in position.

. Correction of open bite by a V shaped excision of bone.



Correction of open bite by V-shaped excision in the horizontal ramus.

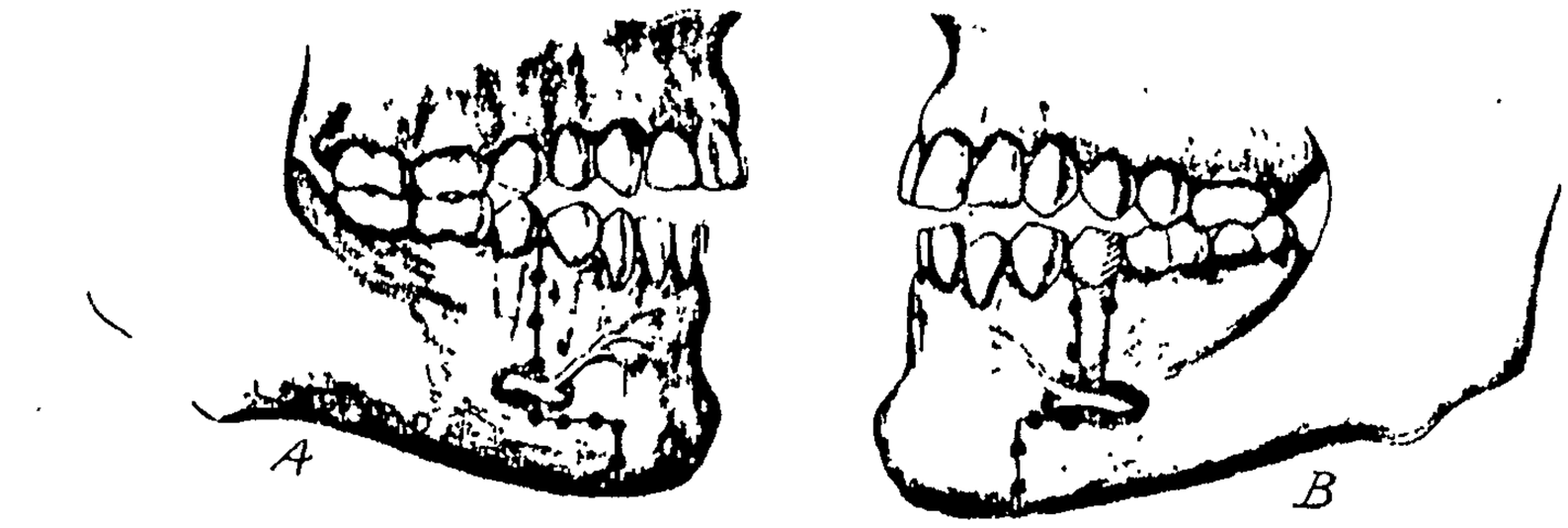
Thoma's "Y" Body Osteotomy for Correction of Apertognathia.

From Thoma 1943.

Diagram 99

performed a similar operation for the correction of retrognathism. The section was an "S" shaped cut combined with extra-oral traction to achieve the final positioning of the fragments. See **diagram 98.** Again no long term follow-up was given.

Thoma (Thoma 1943) performed the first body procedure for the correction of non-skeletal open bite with the express purpose of attempting to preserve the mandibular neurovascular bundle. See **diagram 99.** The procedure was a "Y" sectioned cut with the intersection of the cuts about the neurovascular bundle. The procedure was sufficiently flexible to be

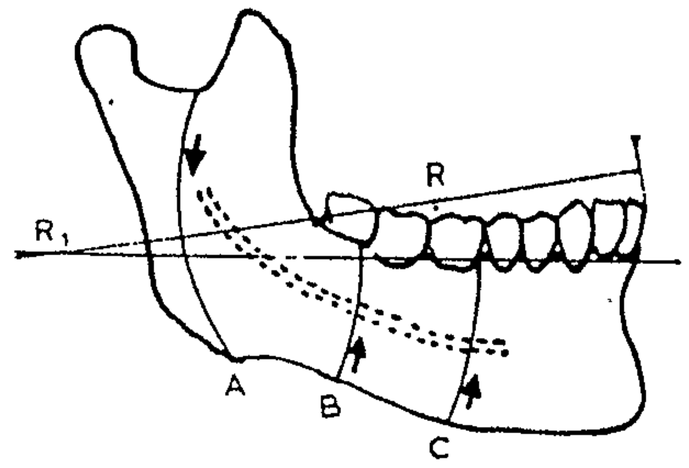


Surgical correction of open bite. *A*, The line of osteotomy with exposure of the inferior alveolar neurovascular bundle. *B*, Line of osteotomy with extraction of a premolar tooth and resection of a triangular segment of bone. The inferior alveolar nerve is exposed. *C*, Vertical and lateral rotation of the mobilized segment to correct the dental occlusal relationships. *D*, Closure of the triangular gap on the left side by rotation of the mobilized fragment.

Converse's Step Body Osteotomy for the Correction of Apertognathia.. 1951.
From Converse, Horowitz & Wood-Smith 1968.

Diagram 100

adapted for the correction of either open bite or closed bite, and mild retrognathism or prognathism. Thoma performed his procedure through an oral and then extra-oral approach. The teeth were first removed and the "V" shaped section of bone removed orally down to the level of the neurovascular canal, care being taken to avoid cutting into the canal. With a second sterile procedure, an incision over the lower border was placed and the mandible exposed by a combination of blunt and sharp dissection. The partially finished bone sections were located and the cuts completed. Thoma used a combination of burs and chisels to complete the bone sectioning, except for a small span that included and protected the neurovascular bundle. When this



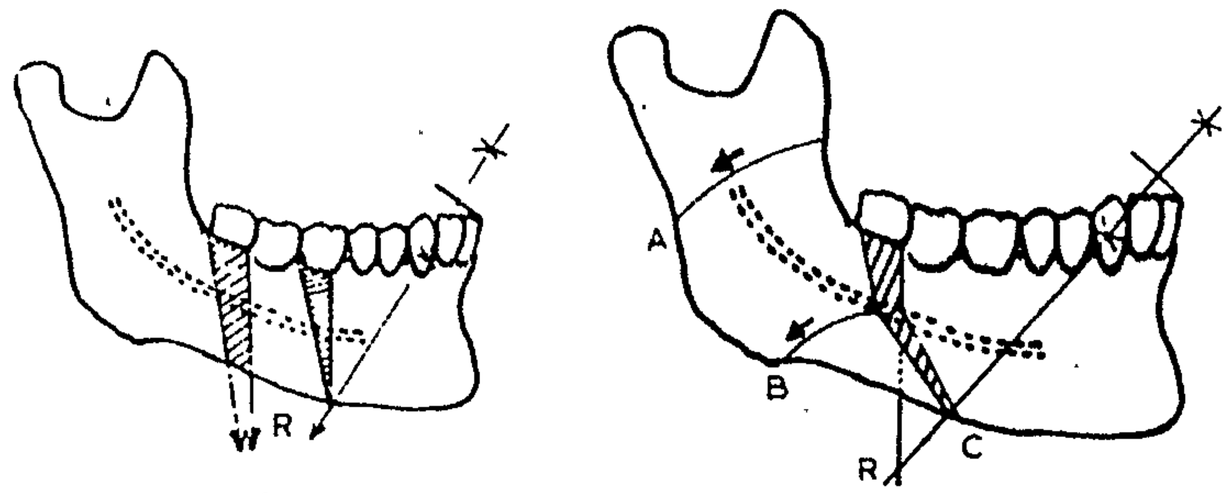
Trauner's Osteotomy Procedures for the Correction of Open Bite Deformity. From Trauner 1969.

Diagram 101

was repeated on both sides the wounds were sutured and drains placed. Thoma then proceeded back to the mouth to apply fixation using detachable appliances with intermaxillary wiring. Thoma reported success with his post-operative healing and no mandibular nerve dysfunction.

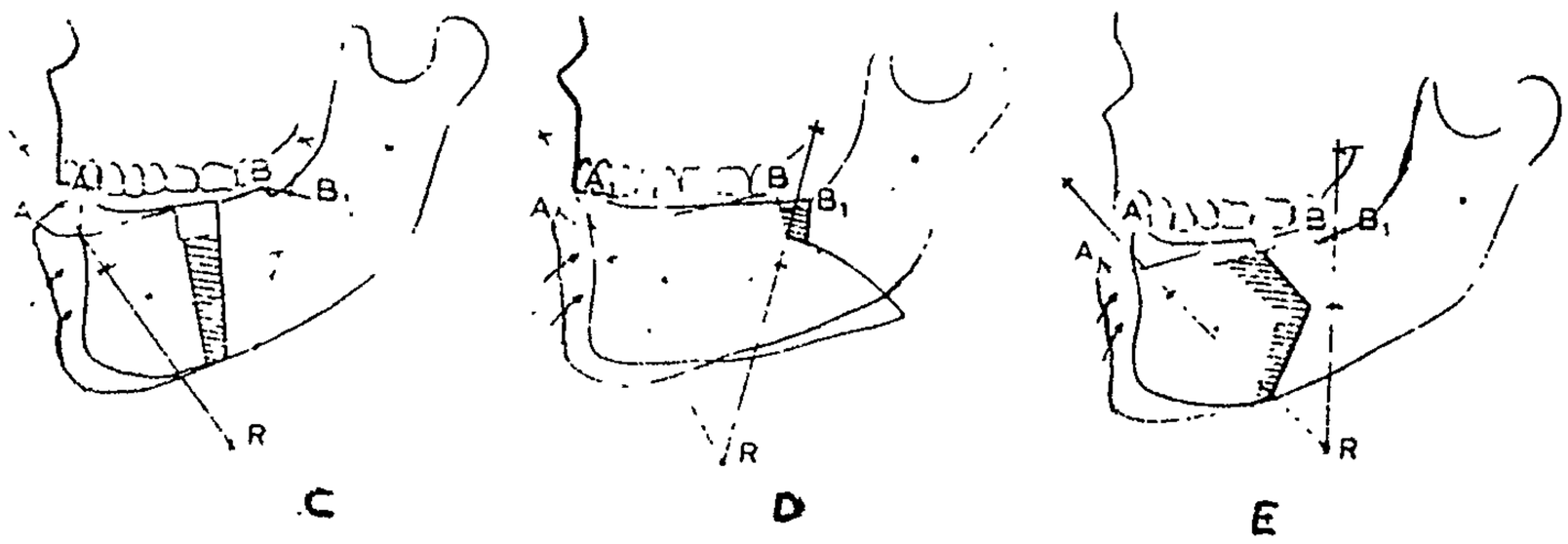
Converse (Converse 1952) reported his body osteotomy for the correction of non-skeletal open bite with preservation of the mandibular neurovascular bundle. See **diagram 100.** The bundle was cut down to and exposed and then set aside while the osteotomy cuts were performed. The section cuts were stepped in the premolar region. Converse made the point that his procedure could be adapted for the correction of asymmetry by using a linear vertical section on one side and a "V" or block section on the other.

Trauner recommended (Trauner 1969) that open bite deformity, where present by itself, be corrected through a curvilinear section the arc of which is calculated with each patient. When the centre of rotation of each patient was determined



A B

A, Wedge-shaped bone excision in the angle and in the body for a case of mandibular prognathism with slight open bite. B, Curved lines of osteotomy (A and B) and angulated bone excision (C) for a similar case.



C D E

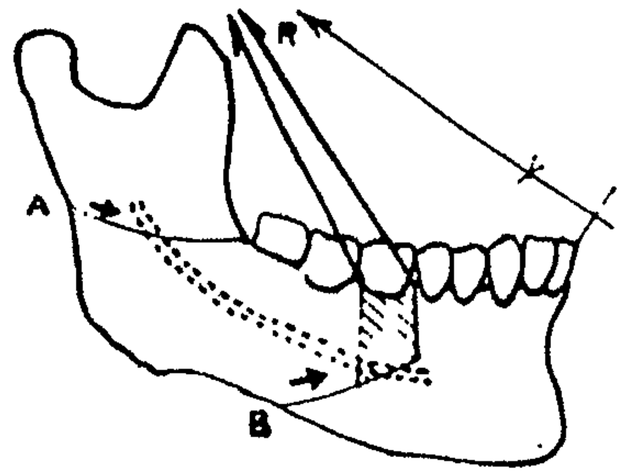
Possible osteotomies in mandibular prognathism with a slight open bite. **C**, Excision of a wedge-shaped piece of bone in the body. The centre of rotation R, lies at the intersection of the axes of the lines A, A_1 and B, B_1. **D**, Bone excision at the angle and curved osteotomy. **E**, Angulated bone excision in the body.

Trauner's Osteotomy Procedures for the Correction of Open Bite and Prognathism. From Trauner 1969.

Diagram 102

according to the degree and type of open bite. The section can be placed along a line of arc about the centre of rotation. The radius of the arc was determined by the need to position the section according to which teeth are to be removed or are already missing where the section is to be in the body of the mandible, or whether the procedure is to be performed in the ramus rather than the body of the mandible. See **diagram 101.**

Trauner recommended that where mandibular prognathism accompanied open bite, then the deformity could be corrected by a number of procedures, mainly in the body. There were



Trauner's Biangled Wedge Osteotomy for the Correction of Open Bite and Retrognathism. From Trauner 1969.

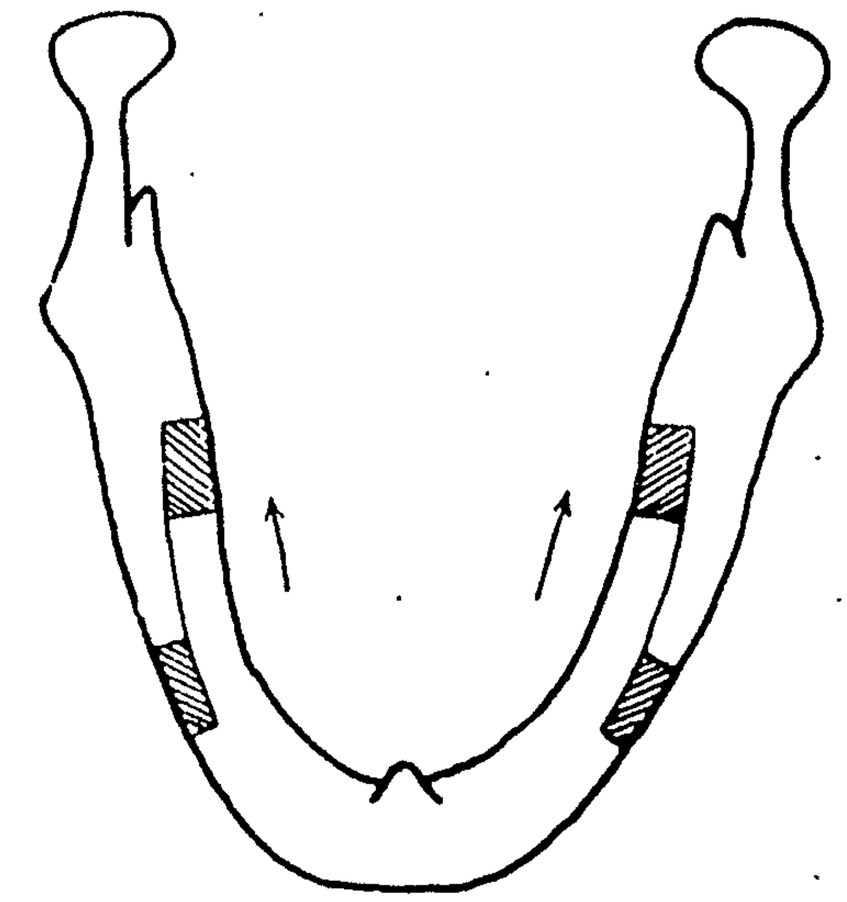
Diagram 103

several procedures of the body that Trauner recommended that would correct both deformities simultaneously. See **diagram 102.**

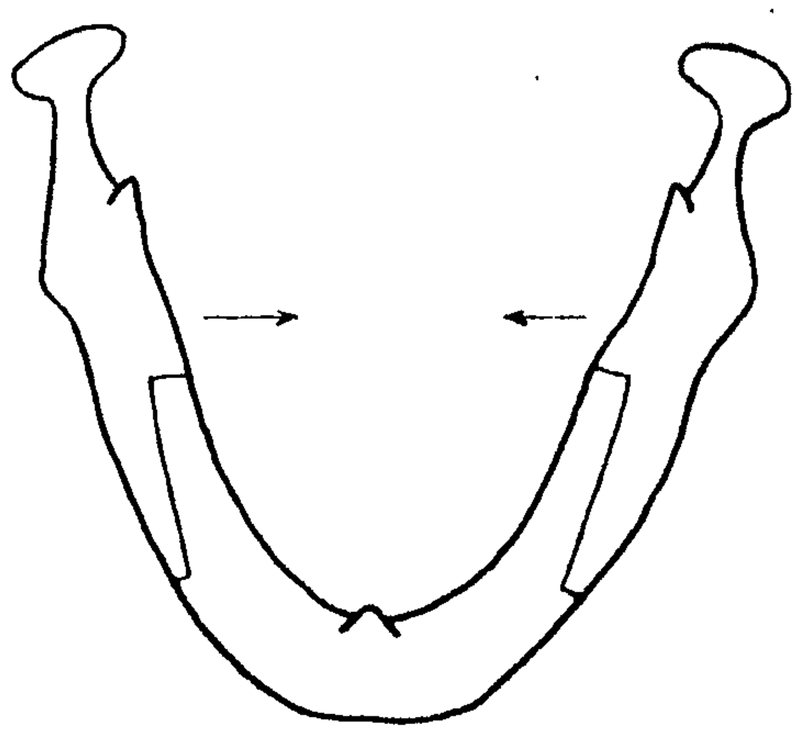
In each procedure, the angulation of the sections determined the amount of correction obtained, and this depended on the degree of severity of the open bite and the accompanying prognathism.

Where the open bite deformity was accompanied by mild to moderate retrognathism then Trauner recommended the bony sections illustrated. See **diagram 103.** Where the deformity called for the correction of anterior open bite in conjunction with retrognathism, then the sections could be bolstered with an iliac crest graft to the required extension.

Sada (Sada 1966) reported a technique of splitting the body of edentulous mandibles in the sagittal plane for the correction of prognathism. See **diagram 104.** Mehnert (Mehnert 1967, 1972) adapted the procedure for the dentate mandible also for the



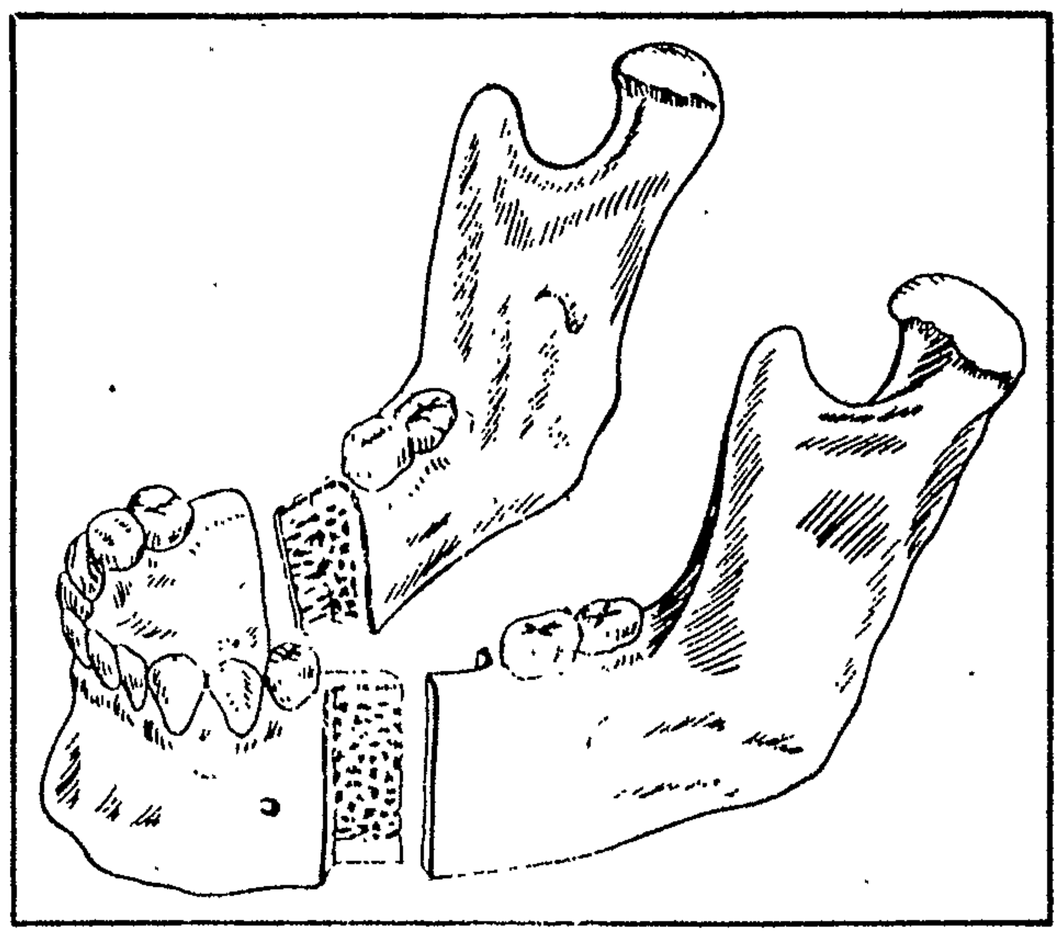
Scheme of sliding osteotomy of body of mandible. View of base of mandible. In first phase, vertical strips of vestibular and lingual compact bone are removed (diagonal lines). In second phase, two layers of compact bone are separated, neurovascular bundle is laid bare (exteriorization) and mental segment is shifted, thus shortening body of mandible



Mental segment has been shifted. Lingual level of mental segment checks dislocation of both articular segments medially in direction of arrows where they are pulled by mylohyoid muscle

Sada's Sagittal Split Body Osteotomy. From Sada 1966.

Diagram 104

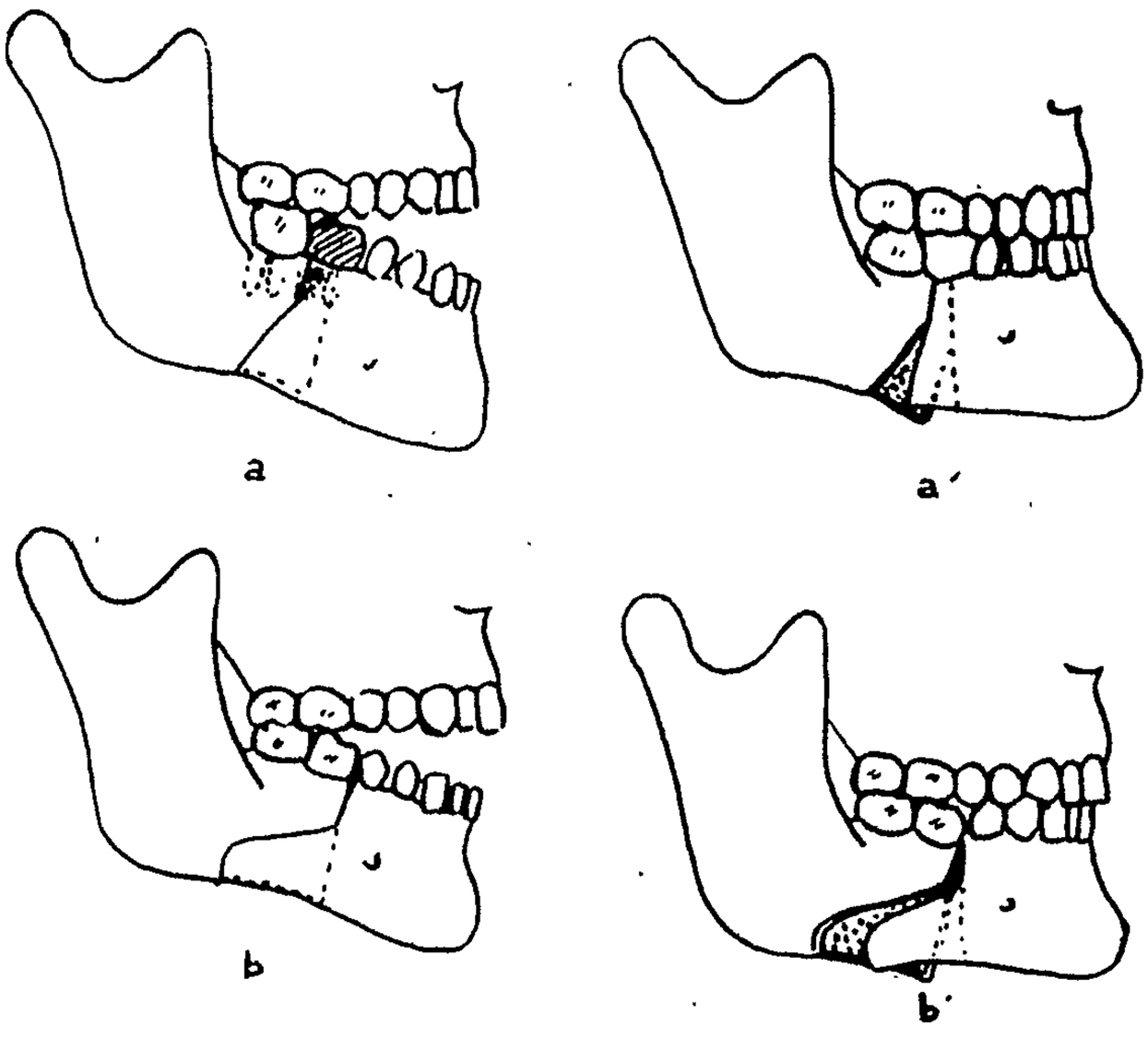


Beke & Yahner's Variation Sagittal Split Body Osteotomy for Correction of Apertognathia. 1969. From Kempf 1977.

Diagram 105

correction of prognathism. In 1969 Beke and Yahner (Beke & Yahner 1969) reported the use of a sagittal split procedure for the correction of both open bite and closed bite deformity. See **diagram 105.** The procedure was accomplished successfully.

In 1970, and again in 1977 with modifications, Delaire (Delaire 1970, 1977) reported using a similar procedure to Mehnert for the correction of both severe open-bite and severe over-bite. See **diagram 106.** It did not matter whether there was mild prognathism or retrognathism present or not, and depending where the section was taken, the procedure could correct skeletal/posterior open bite as well as the non-skeletal/anterior open bite deformity for which it was best suited. Kempf (Kempf 1977) reported the same



Sagittal osteotomy of the body of the mandible.

a + a') With extraction of first molar. The buccal bone cut is slightly distal to the lingual cut.
b + b') Without tooth extraction; in the alveolar process, both osteotomies are placed at the same level. Below the level of the apices, the buccal bone cut is directed backwards to increase the surface of contact.

Delaire's Variation Sagittal Split Body Osteotomy for Correction of Apertognathia. 1970.
From Delaire 1977.

Diagram 106

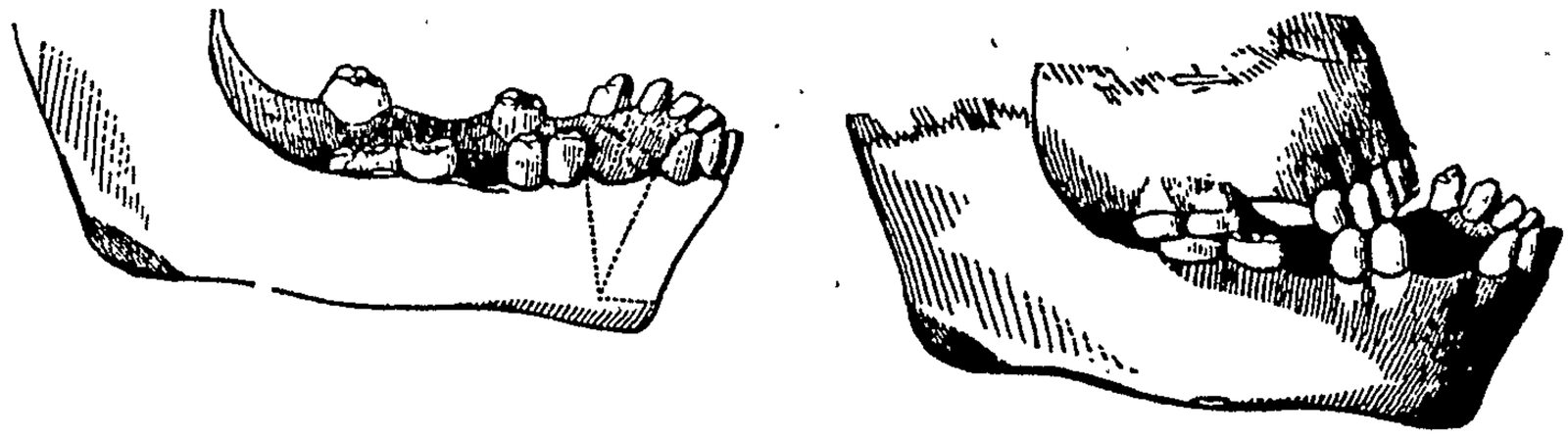
sagittal split procedure as Beke and Yahner for the correction of open bite deformity. There appears to be very little difference between the procedure reported by Beke and Yahner and that of Delaire.

Advantages of the operation were that the procedure was quick to perform; bony consolidation was rapid; and the results were stable. Indications for the procedure were those of non-skeletal/anterior open bite. These were a curved mandibular plane with antegonial notching and with or without mild prognathism or retrognathism. The latter report (Delaire 1977) presented a modification of the first procedure which was identical to Mehnert's procedure. The procedure is performed intra-orally. The buccal cut is distal to the lingual cut, and the section is made through either an already available extraction site, or a tooth or teeth are

extracted to make the required operating area available. According to Delaire extraction is not necessary as the procedure can be performed distal to the last molar. The lingual cut is vertical and down to the level of the lower border. The buccal cut is angulated posteriorly to the lower border also. The cuts are joined together. Once the cortical bone cuts are made into cancellous bone, the osteotomy cuts are completed with a fine chisel. Intermaxillary fixation was used for 8 to 15 days, and then replaced with a prefabricated mandibular splint.

Sandor et al (Sandor, Stoelinga & Tideman 1982) in a review of the step osteotomy of the body, recommended the use of the step procedure for the correction of anterior open bite deformity. The anterior fragment is tilted vertically, even elevated if necessary, with the removal of sufficient bone at the extraction site to allow maximum abutment of the fragments and levelling of the occlusal plane. The step osteotomy was recommended as the fracture is inherently a stable fracture and tended to resist the superior pull of the elevator muscles of mastication, the Pterygo-masseteric sling in particular, and also the depressor muscles of the Hyoid group and the Digastric muscle. Sandor et al specifically advised against the use of the reverse step osteotomy as this produced an unstable fracture and did not resist the action of the muscle groups mentioned and would tend therefore to introduce a greater level of instability and potential relapse. (Sandor, Stoelinga & Tideman 1982).

On the whole body procedures are suitable for the correction of anterior or non-skeletal open bites as the procedures correct the deformity at the site of the problem, and allow



Hullihen's Subapical Osteotomy. 1848.
From Hullihen 1900.

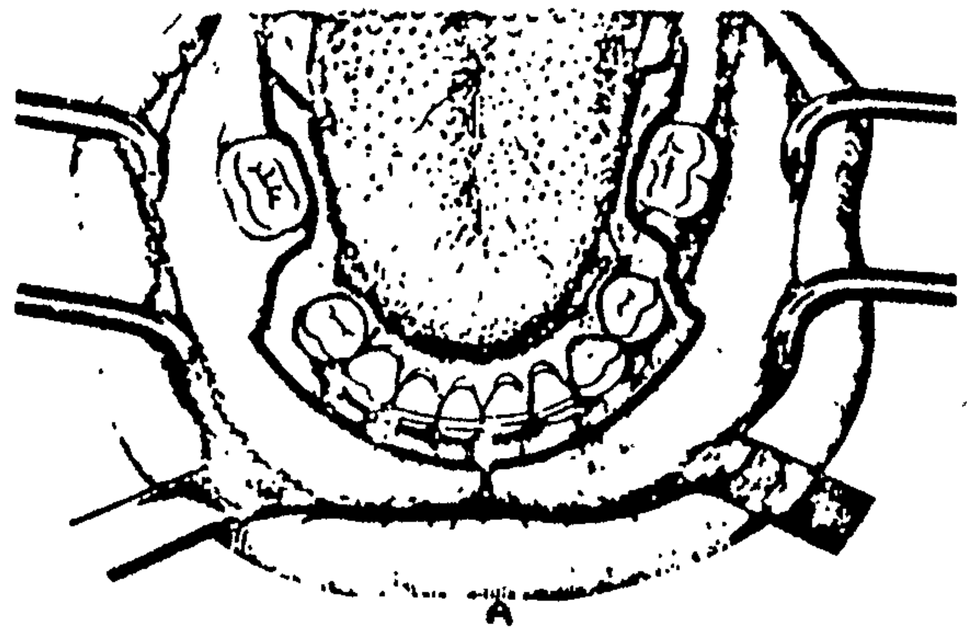
Diagram 107

flexibility in the procedure to correct variations of the problem. Further flexibility was gained with the introduction and subsequent advancement of the subapical procedures.

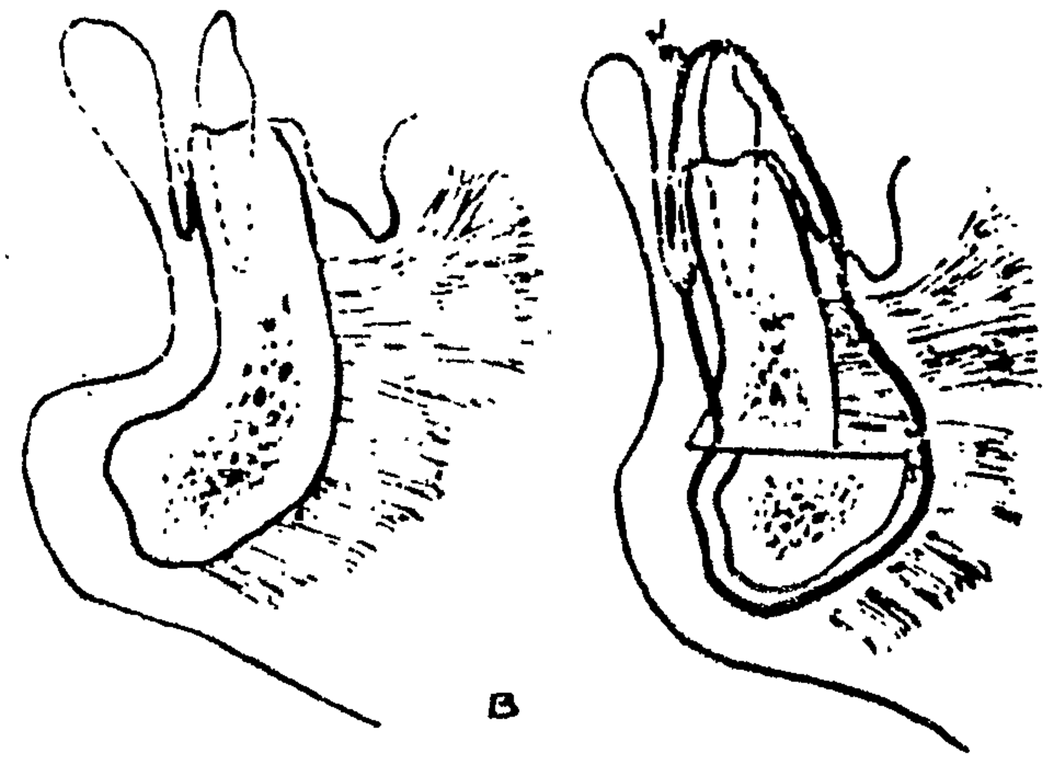
Segmental Subapical Procedures.

The first procedure ever recorded for the correction of a mandibular deformity was performed by a Dental Surgeon of Wheeling, West Virginia, U.S.A. by the name of Hullihen (Hullihen 1849). He corrected a non-skeletal anterior open bite, with some degree of protrusion, which was the result of scar tissue contraction on a badly burned face. The procedure was an anterior mandibular alveolar osteotomy with a "V" shaped wedge removed from the premolar region, through an oral approach. See **diagram 107.** The cut proceeded down for about two-thirds of the mandible and was repeated on the opposite side of the mandible at the same position. The two "V" cuts were joined up by a horizontal, subapical cut and the fragment then positioned superiorly. The fragment was still attached to the soft tissues lingually. Thus the inferior border of the mandible was left intact. Fixation was by means of a cast metal (continuous) cap splint. The result was very satisfactory, especially as the burn scar tissue on the neck was treated at a later date by a pedicle flap graft, with two further operations to correct the scarring of the lip. The procedure, according to Babcock (Babcock 1909), was performed without the use of an anaesthetic, without the use of antiseptics and without the use of haemostatic forceps.

Nearly 100 years later Köle (Köle 1959a, 1959b, 1965) published his series on subapical osteotomies (or anterior mandibular alveolar osteotomies) for the correction of non-skeletal



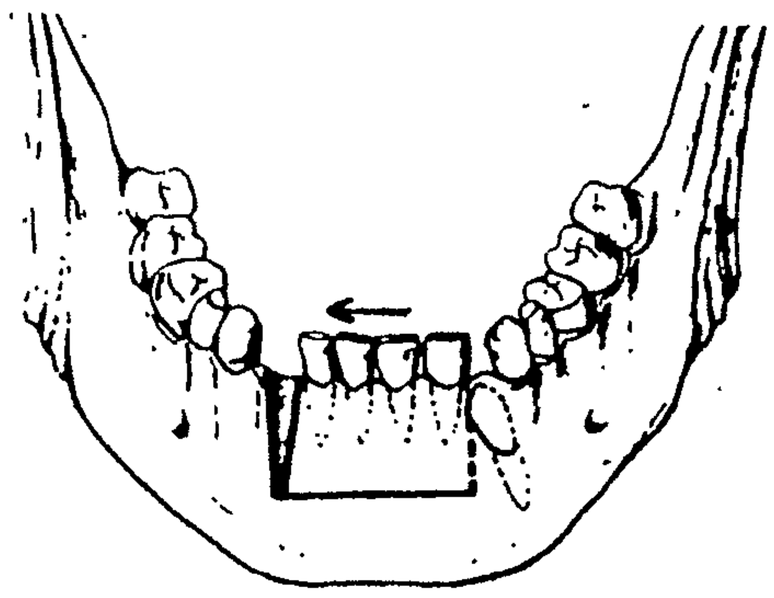
A



B

A - New mucosal incision (Kole).
B - Cross section showing osteotomy and circumferential wiring.

Kole's Subapical Osteotomy for Retruston.
From Kole 1959.



Kole's Subapical Osteotomy for Lateral Movement. From Kole 1959.

open bite deformity. See **diagram 109.** Köle attributed the original idea to Hofer (Hofer 1936, 1942) and before that Cohn-Stock (Cohn-Stock 1921), but clearly the concept belongs to Hullihen (Hullihen 1848) as the original performer. Köle presented a series of subapical osteotomies (or anterior mandibular alveolar osteotomies). Köle's procedures were more refined than his predecessors. The procedures could be adapted so that the anterior apical fragment could be shifted in almost any direction required, with or without grafts, with or without the need for extraction of teeth. However the amount of movement is moderate at best. (Köle 1965). The procedure has been best used in the correction of open bite deformity often combined with other procedures such as genioplasty, or even ramus or body procedures where the mandibular deformity is severe. These indications were later expressed by Obwegeser in a series of articles on the correction of alveolar anomalies. (Obwegeser 1968; 1969a; 1969b).

Lines and Steinhäuser (Lines & Steinhäuser 1974) advocated the procedure for several reasons. These being the ability of Köle's procedure to (a) not only correct open bite, but (b) to reduce facial convexity, (c) to reduce the lower anterior facial height and (d) with genioplasty, to restore the chin contour. Specific recommendations or indications for the operation were:

1. Steeply curved mandibular occlusal plane.
2. Large anterior vertical dimension (so that there is sufficient room to perform the surgery subapically and not destroy the neurovascular supply to the teeth.

Specific contra-indications were:

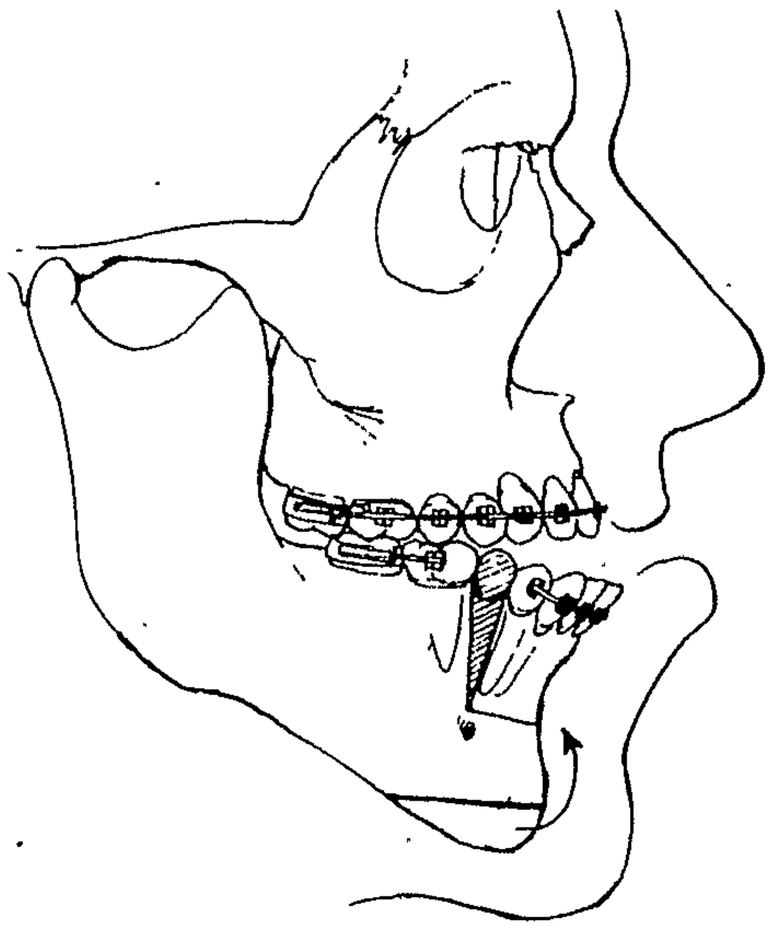
1. Obtuse gonial angle (where the open bite is based on the molars only).

2. The mandibular occlusal plane is straight and not curved.
3. The mandible is otherwise normal.

Bell and Dann (Bell & Dann 1973) also favoured the Köle type of operation for the correction of anterior open bite deformity (as distinct from skeletal/posterior open bite deformity where the latter has a straight mandibular occlusal plane and the former has a curved occlusal plane usually with accompanying antegonial notching). Bell and Dann demonstrated the flexibility of the subapical osteotomies with the correction of anterior protrusion and retrusion of the anterior inferior and superior segments whether they were accompanied by open bite deformity or not.

Bell and Dann noted no problem arising from revascularisation of the area, noting no loss of the segment provided that a soft tissue pedicle (buccal or lingual) was maintained. A point that Bell and Levy had previously established on Rhesus Monkeys (Bell & Levy 1970). In some cases the segment itself was further divided again with no loss of vitality. Antibiotics were given post-operatively routinely. Fixation was by means of either acrylic occlusal splints, cast metal splints or fixed orthodontic type appliances, and was maintained for 6 to 8 weeks.

Meyer (Meyer 1972) made use of the symphysis as a donor site to graft bone under subapical fragment to provide vertical boosting for the fragment. This procedure was recommended where there was no other deformity except the open bite, and the deformity was severe. This report was followed subsequently by that of Schroll who also advocated the use of the symphysis for a graft. (Schroll 1973).



ANTERIOR SUBAPICAL MANDIBULAR SURGERY

Epker & Wolford's Subapical Osteotomy.
From Epker & Wolford 1980.

Diagram 109

Pedersen (Pedersen 1973) demonstrated the versatility of the subapical procedures by varying the number of teeth, and therefore the width of the segment, to correct single and multiple tooth displacements as well as correcting open bite deformity at the same time where necessary.

Epker (Epker & Fish 1977) advocated the use of the anterior mandibular and/or maxillary subapical procedures for the correction of anterior open bite where the aesthetic and functional requirements of the case can be satisfied. See **diagram 109.** According to Epker, these anterior subapical procedures are the procedures of choice for the correction of open bite because of their results and stability. Where the open bite is accompanied by a retrognathia then a posterior maxillary ostectomy was indicated or combined with simultaneous anterior subapical osteotomies. Where the

open bite is in conjunction with a prognathic mandible then according to Epker an anterior subapical osteotomy is indicated with a genioplasty. Where the anterior subapical osteotomy with genioplasty is unsuitable, then a body procedure is recommended. Epker did not recommend the use of ramus procedures for the correction of open bite due to the high relapse rate.

In a subsequent article Epker expanded on the factors that make up non-skeletal open bite with prognathism and the procedures required to correct the problems (Epker & Fish 1978). Epker recommended that any orthodontics undertaken should be limited to the correction of local crowding problems, which will probably increase the degree of deformity. Epker again recommended that where possible the deformity should be corrected with an anterior subapical procedure in combination with genioplasty. This may have to be combined with a posterior maxillary ostectomy to achieve a satisfactory result. Combination procedures, with a view to correcting the deformity at the site of the deformity, is the preferred approach by Epker. The commonly used procedures (at that time) were proving unsatisfactory for Epker.

Where the problem of the open bite was due to a curved mandibular occlusal plane, then a subapical procedure of the anterior mandible perhaps combined with a maxillary procedure and/or a genioplasty would be the surgical treatment of choice. Where the open bite is skeletal and associated with a straight mandibular occlusal plane, then a body procedure was recommended. However contrary to Epker's previous recommendation (Epker & Fish 1977) the procedure recommended for the body was a sagittal split procedure involving both the body and the ramus and appeared from the diagram

to be a Dal-Pont type variation of the Trauner-Obwegeser sagittal split osteotomy. No mention was made in the text of the exact nature of the sagittal split procedure.

Again a combination of procedures involving the maxilla may be indicated depending on the nature and siting of the deformity. Epker reported very good stability over 3½ years. (Epker & Fish 1978).

As a general rule, subapical and body osteotomies are suitable for non-skeletal open bite where the ramus procedures are not. Conversely ramus procedures are suitable for skeletal/posterior open bite deformities where body and subapical procedures are not. The subapical procedures have the advantage of being more selective in those parts of the body of the mandible that are to be corrected. The subapical series of procedures have developed into adjuncts to the more substantial and gross body and ramus procedures and were the forerunners of the later alveolar procedures (See Alveolar Expansions and Contractions).

Bell et al (Bell, Proffit & White 1980) reported only two major complications of the Köle procedure, and they stressed that these were rare. They were;

(a) Loss of tissue related to inadequate post-surgical blood supply - this was noted in two instances, complete tissue detachment for placing a graft, and inadvertent tearing of mucosal tissue during surgery;

(b) Prolonged paraesthesia of the lower lip - usually when there was an abnormal course of the mental nerve.

Bell et al also noted several 'secondary' complications that were

even less emphasised. These were;

(a) wound dehiscence when inadequate post-operative pressure dressing were placed,

(b) substantial loss of buccal sulcus requiring a vestibuloplasty.

In all Bell et al were very pleased with the Köle procedures and recommended them for the correction of anterior open bite deformity with or without other accompanying deformities such as mild prognathism or mild retrognathism. (Bell, Proffit & White 1980).

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APERTOGNATHISM (OPEN BITE DEFORMITY)

Skeletal Open Bite.

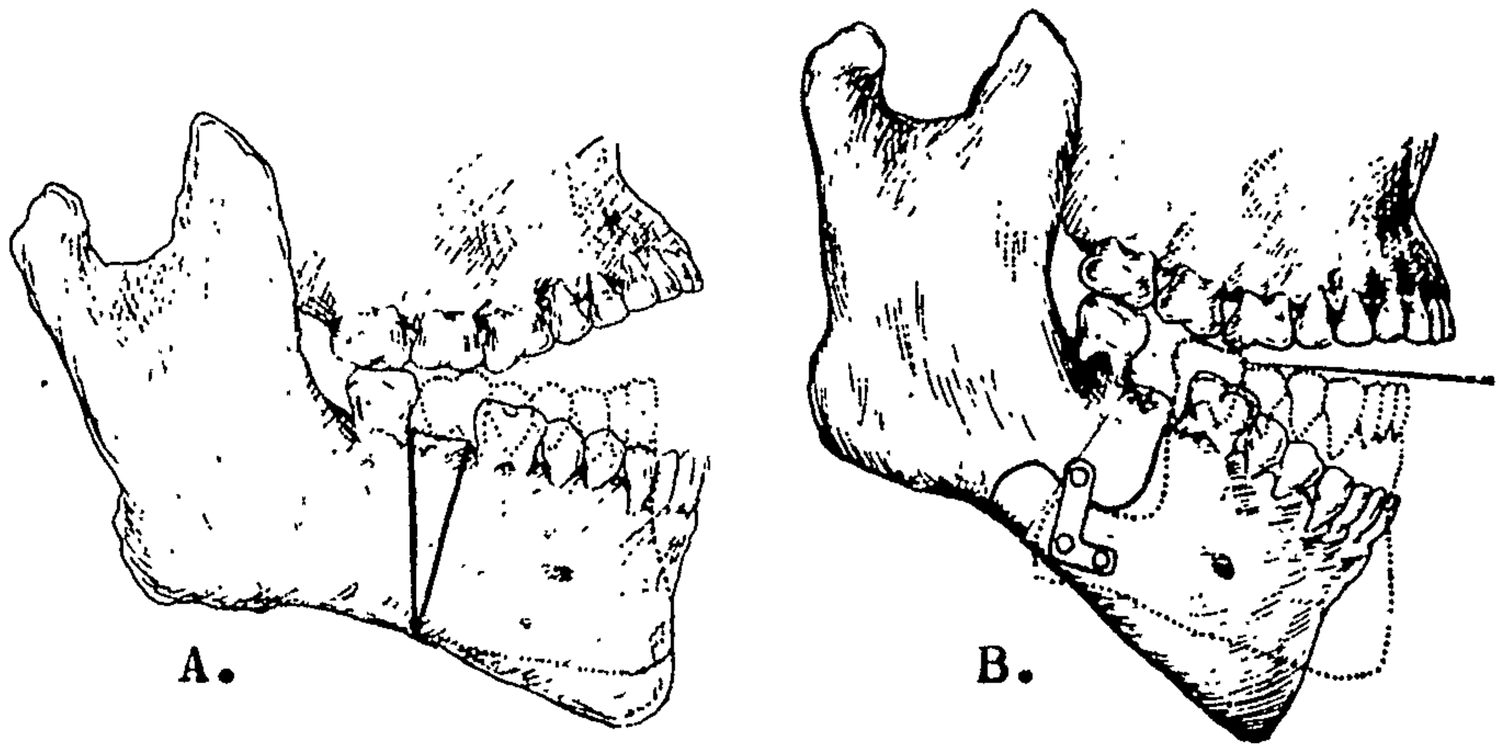
Body Procedures.

In his textbook of 1923 (Blair & Ivy 1923) Blair had limited the number of procedures that he recommended for the correction of posterior open bite, to two:

1. The "V" shaped body procedure.
2. The "S" shaped body procedure.

Fixation for the latter was with an "L" shaped Lane plate screwed into the body across the cut, along with head cap fixation to the chin, or circummandibular wiring at the symphysis to the anterior teeth of the maxilla if they were sound enough.

Blair used his "V" shaped body osteotomy in the molar region for the correction of skeletal open bite deformity but found the procedure to be unsatisfactory. See **diagram 110.** It was to avoid relapse that Blair developed the curved body osteotomy. The radius of the body section centred on the last molar and the concavity of the cut faced anteriorly. As a further advance, Blair recommended his "S" shaped body procedure. See **diagram 110.** In this technique the bone cut commenced at the superior border of the mandibular body in the molar region and proceeded downwards and then backwards below the level of the apices. The final section was a downwards cut to finish on the lower border below the third molar - retromolar region. This procedure allowed greater bony contact than his previous procedures, and could be varied to suit the degree of the open bite deformation and also to some degree the position of the open bite i.e. skeletal open bite or non-skeletal open bite. There



A. Blair's "V" Body Osteotomy for Correction of Apertognathia.
From Blair 1923.

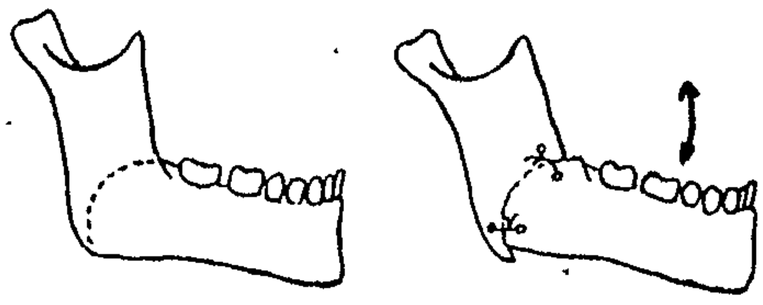
B. Blair's "S" Body Osteotomy for Correction of Apertognathia.
From Blair 1923.

Diagram 110

was also none of the posterior open bite complications that occurred with the curved body osteotomy. (Blair & Ivy 1923).

Several authors (Limberg 1928; Hensel 1937; Trauner & Obwegeser 1957) have mentioned Cryer as being responsible for a curved section procedure of the angle of the mandible for the correction of skeletal/posterior open/closed bites and minor protrusion or retrusion. See **diagram 111.** The latter two authors also mentioned Schmuziger, Wassmund, and Ritter as being responsible for the development of the same procedure. None have given reference other than to give the names. The procedure is similar to the one described by Blair (Blair 1915) but placed further posteriorly into the ramus with the curve arcing about a point, not near the molar/retromolar region, but lower and slightly more posterior to the

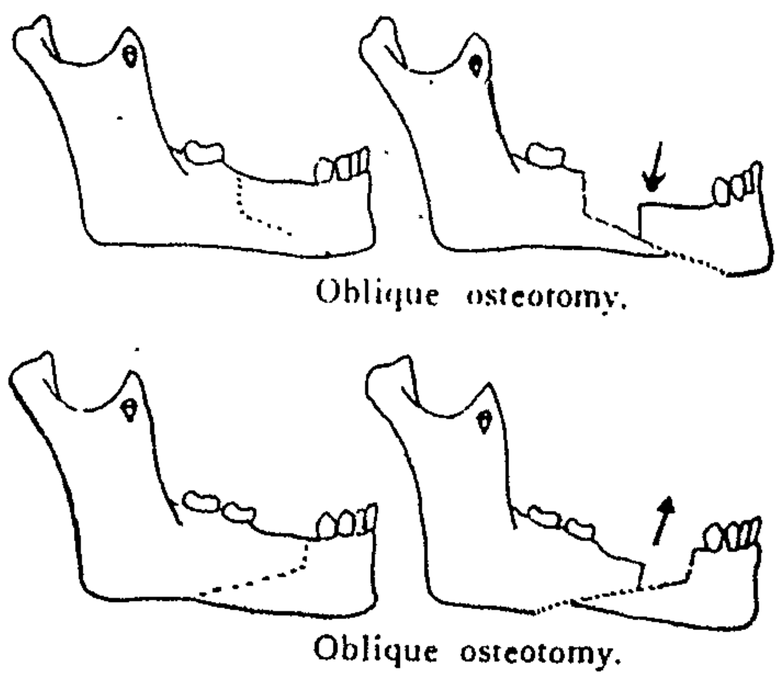
point described by Blair. Very little else is noted in the reference other than a diagram, and that the procedure was reported on or before 1928.



Cryer's Curved Ramus Osteotomy.
From Limberg 1928.

Diagram 111

In a report on the correction of asymmetry, Limberg (Limberg 1928) showed a procedure by Eiselsberg and Pichler (Eiselsberg & Pichler 1912) that corrected either skeletal or non-skeletal open bite when the open bite deformity was accompanied



Eiselsberg & Pichler's Oblique
Body Osteotomy for Apertognathia.
From Limberg 1928.

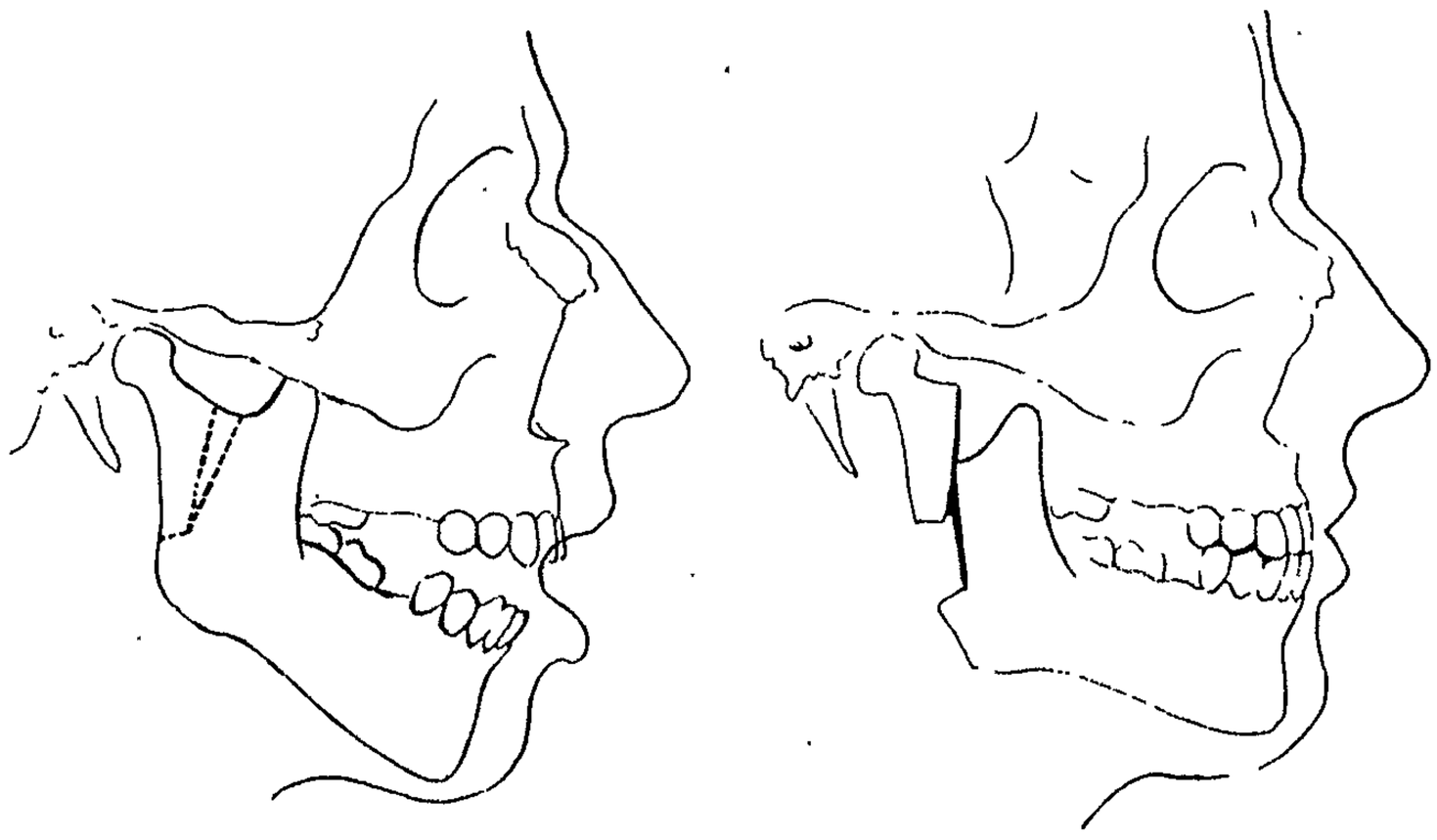
Diagram 112

by substantial retrognathism. The procedure was an oblique sectioning of the mandible in the molar - premolar region. See

diagram 112. The cut commenced in the canine region and proceeded vertically downwards for approximately a centimetre and then proceeded backwards at an angle down to the horizontal to finish at the lower border. The commencement of the vertical cut and the angle of the slanted cut depended on the degree of retrusion that required correction, and the degree of open bite that was present.

Sandor et al (Sandor, Stoelinga & Tideman 1982) recommended the step body osteotomy for the correction of posterior or skeletal open bite deformity where the anterior segment is in good alignment (also suitable for when the anterior segment is also in open bite). Such an open bite, strictly a lateral open bite, is a very uncommmon open bite deformity but is still considered a skeletal deformity rather than a non-skeletal or anterior open bite deformity. The step procedure where performed for this deformity is not significantly different from the procedure performed for the correction of anterior open bite. The difference lies in the movement of the fragments after the sectioning. For the correction of posterior or lateral open bite, the posterior fragment is swung up into occlusion and the anterior fragment either left in situ or appropriately adjusted; usually by being taken forward to accommodate the slightly forward movement of the posterior fragment as it is swung up into position. (Sandor, Stoelinga & Tideman 1982).

In general however, body procedures are not suitable for the correction of skeletal or posterior open bite deformity. These deformities are best corrected by ramus procedures.



Oblique vertical section of the ramus. (After Limberg.) 1925.

Limberg's Subcondylar Osteotomy.
From Limberg 1925.

Diagram 113

Ramus Procedures.

Babcock (Babcock 1909) recommended that his horizontal ramus osteotomy could be used for the correction of skeletal/posterior open bite, although he did not attempt the procedure. According to Thoma (Thoma 1943), Korth (Korth 1921) may well have been the first to use Babcock's procedure for the correction of skeletal open bite deformity. Due to the propensity of the horizontal ramus procedure to create open bites post-operatively, the long term success of this procedure must be in doubt.

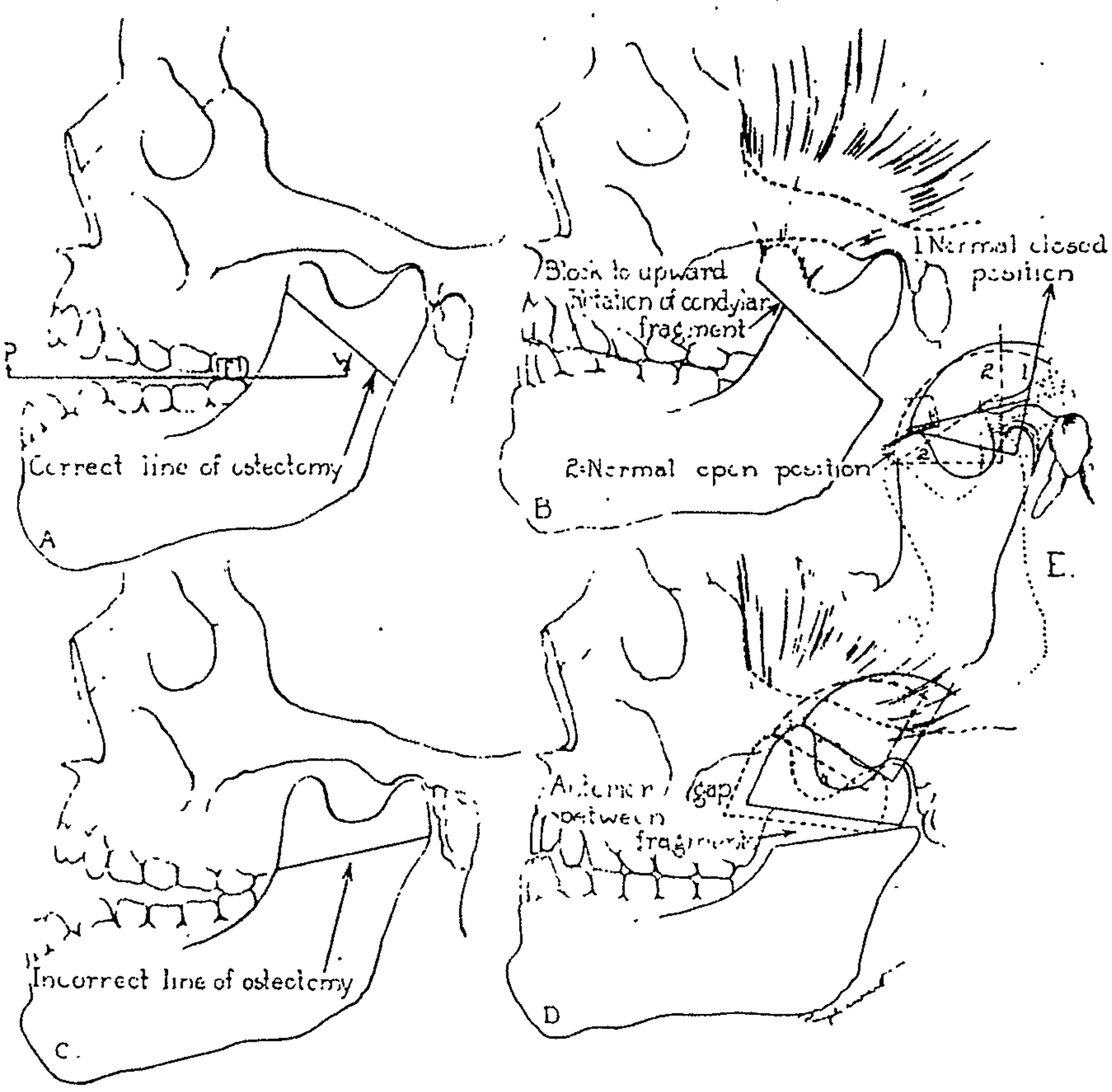
Limberg (Limberg 1925) reported his Russian experiences with correcting skeletal open bites using his ramus procedure. The procedure was a subcondylar osteotomy and the forerunner of Kostecka's subcondylar osteotomy and the subsequent vertical ramus procedures. The surgery was performed by an

extra-oral approach and the cut enabled the mandible to be brought forwards or backwards while correcting the open bite. See **diagram 113.** Limberg did not correct any protrusion or retrusion at the time of the report, but in a subsequent report (Limberg 1926, 1928) he used a costal graft to correct both skeletal open bite and microgenia. Limberg recommended overcorrection where the procedure was used for the correction of open bite. He pointed out that the obstacles to success were the stylomandibular ligament and the elevator muscles attached to the ramus.

Where the degree of retrusion or microgenia accompanying the open bite was small, then Limberg felt that the ramus procedure was better suited. Where the degree of retrusion was greater than the degree of open bite, then a body procedure was better indicated.

Kostecka firstly in 1931 in the German literature and later in 1934 in the English literature, reported the use of his sub-condylar procedure using a blind approach, for the correction of skeletal open bite deformity. Kostecka used a Gigli saw for the procedure using the blind approach previously described, in the chapter on Prognathism, by Blair (Blair 1915). Kostecka felt like Limberg, that skeletal open bite was best corrected through a procedure that did not alter the dental arch. However none of the ramus procedures correct open bite caused by angulation of the dental arch (non-skeletal or anterior open bite).

Hensel (Hensel 1937) recommended the use of an oblique horizontal osteotomy of the ramus with the obliquity

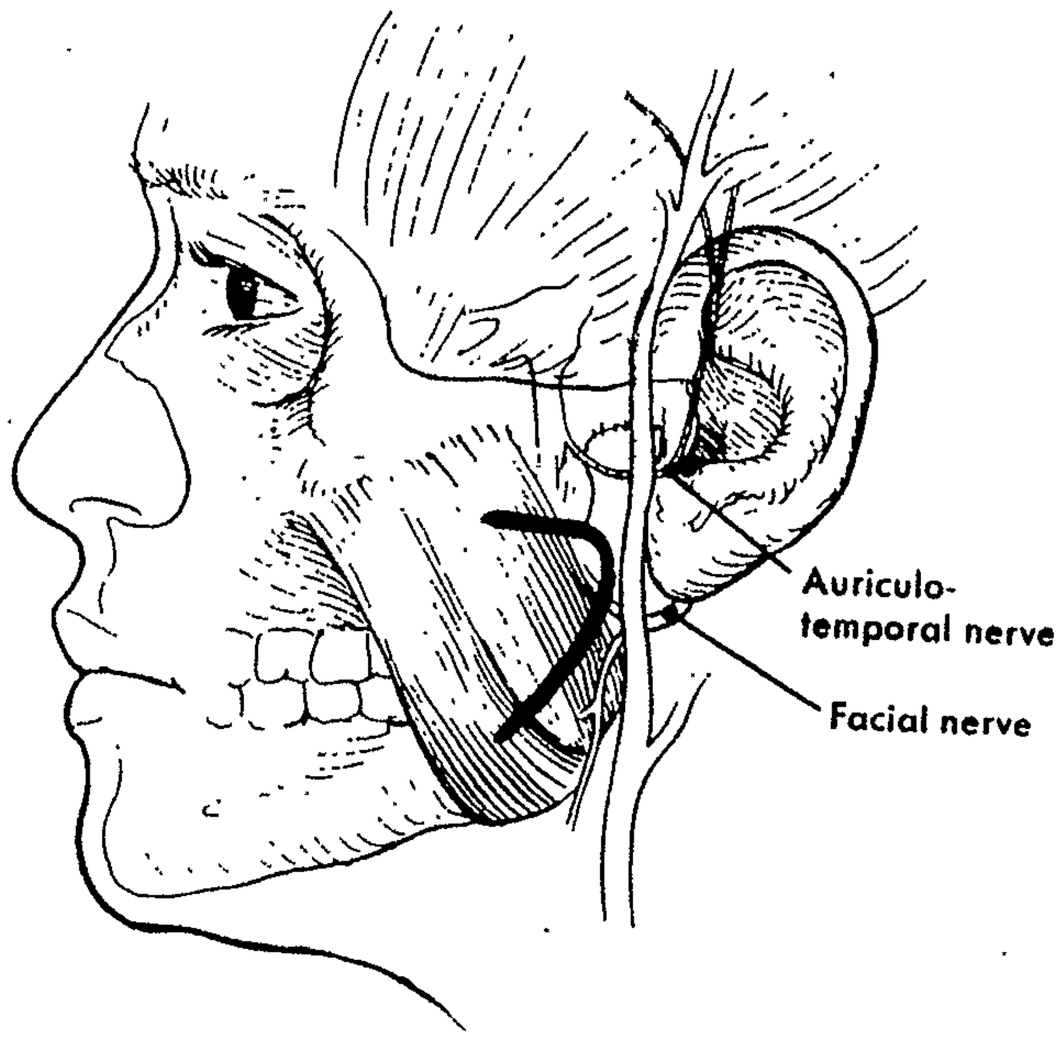


A, Leverage action of skeletal (dental) traction after osteotomy; *B*, correct direction of osteotomy illustrating a lengthening of the ascending ramus and a blocking to upward rotation of the condylar fragment; *D*, result of an incorrect direction of osteotomy, leverage action effective on lower fragment but without a block to displacement of the upper fragment; *E*, normal extreme positions of mandible with respective sectors of rotation 1 and 2. Compare with abnormal positions of *D*.

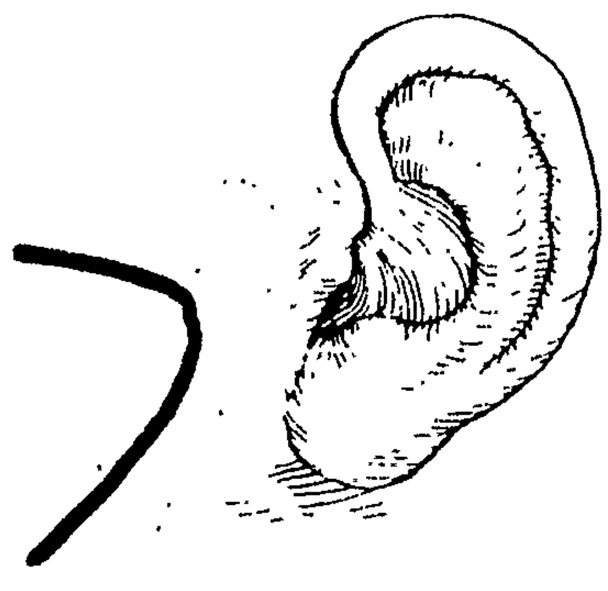
Hensel's Oblique Ramus Osteotomy for the Correction of Apertognathia.
From Hensel 1937.

Diagram 114

precisely measured to match the degree of open bite. See **diagram 114.** He did not favour the blind Gigli saw method of Kostecka but preferred his own extra-oral approach. See **diagram 115.** The incision was one-quarter of an inch anterior and then inferior from a point three-eighths of an inch immediately anterior to the lobe of the ear. The cut was made in the bone with a Joseph's bayonet hand saw.

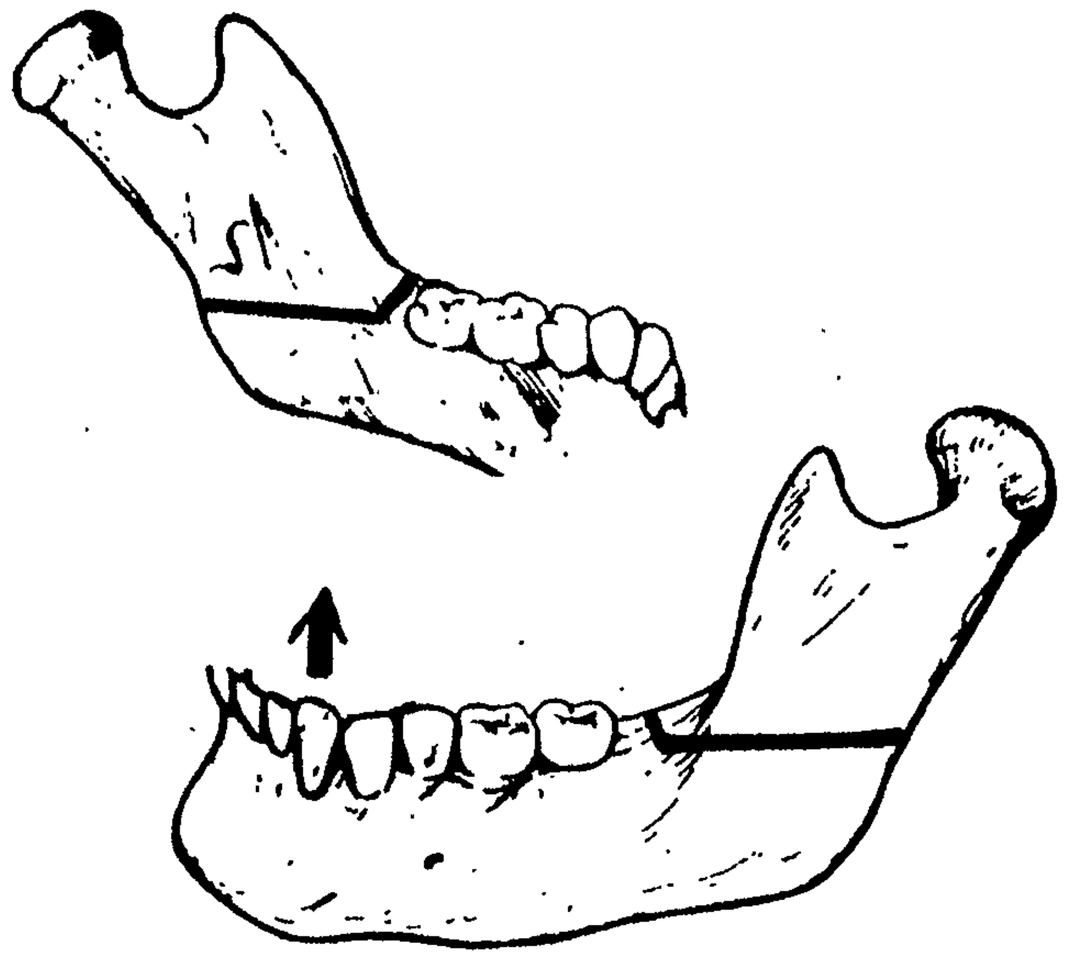


Hensel's Preauricular Approach.



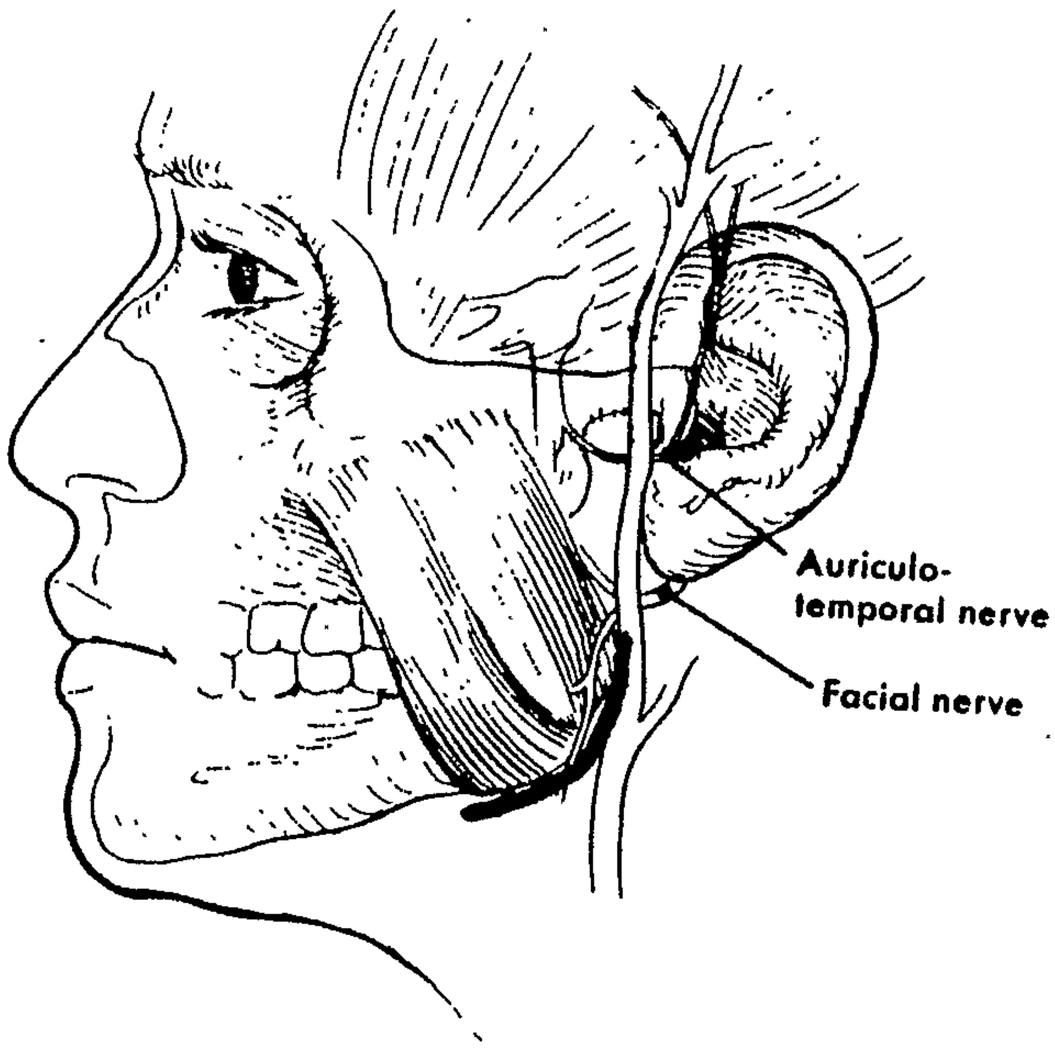
Hensel's Preauricular Approach.
After Hensel 1937.

Diagram 115



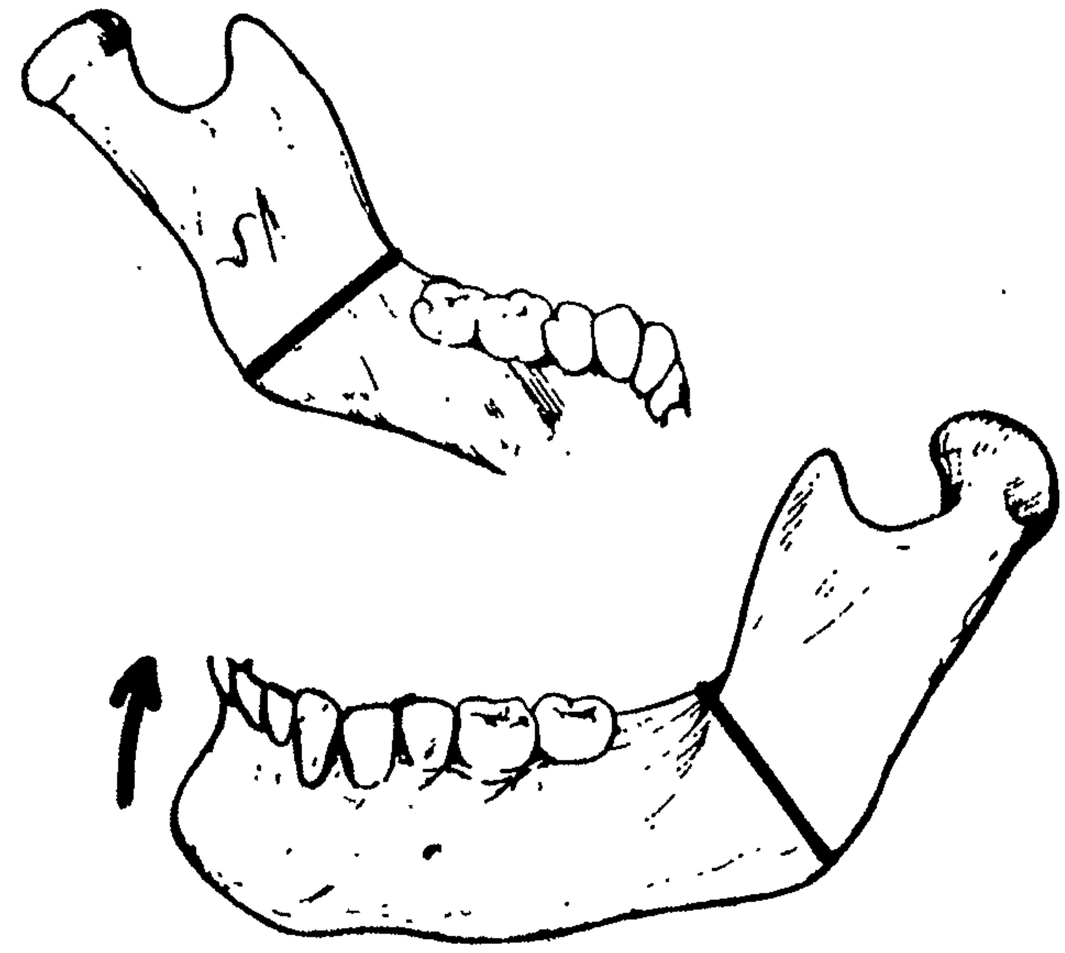
Dingman's Horizontal Osteotomy for
Correction of Apertognathia.
After Dingman 1944.

Diagram 116



Dingman's Approach for His Horizontal
Osteotomy of the Ramus.
After Dingman 1944.

Diagram 117

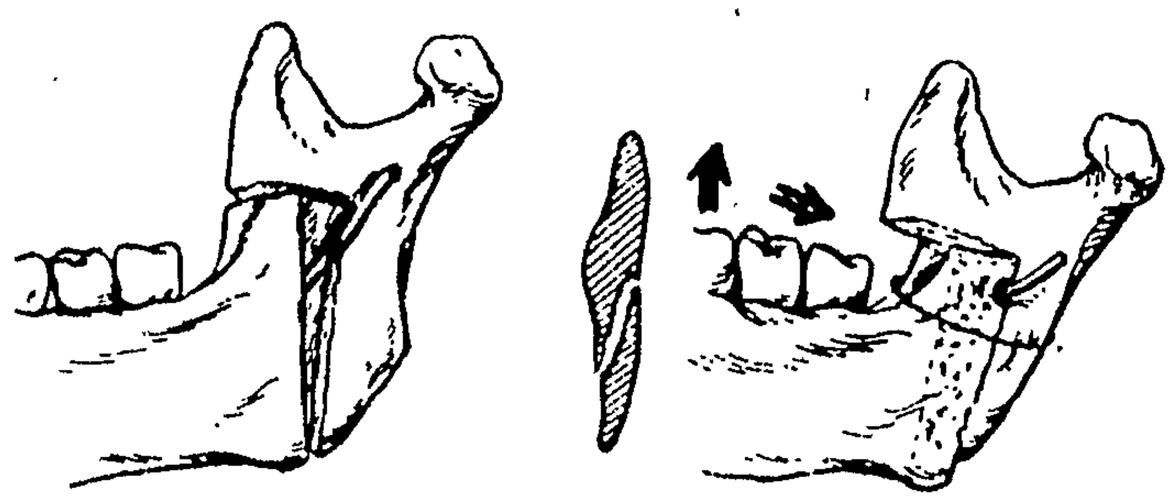


Winter's Oblique Angle Osteotomy.
After Winter 1947.

Diagram 118

Dingman (Dingman 1944a) recommended that skeletal open bite deformity where combined with prognathism be corrected with a horizontal osteotomy that commenced at the inner angle of the mandible (the retromolar region) level with the buccal sulcus. See **diagram 116.** The approach was an external one via an incision that commenced two centimetres above the external angle of the mandible at the posterior border and continued downwards to follow the lower border and finish two centimetres anterior to the external angle of the mandible. See **diagram 117.** The dissection was carried down and through masseter to the bony angle. The section was carried out with a Gigli saw, the mandible retruded to the desired position and the fragments wired. There was no long term follow-up. (Dingman 1944a).

Winter (Winter 1947) in his textbook on Oral

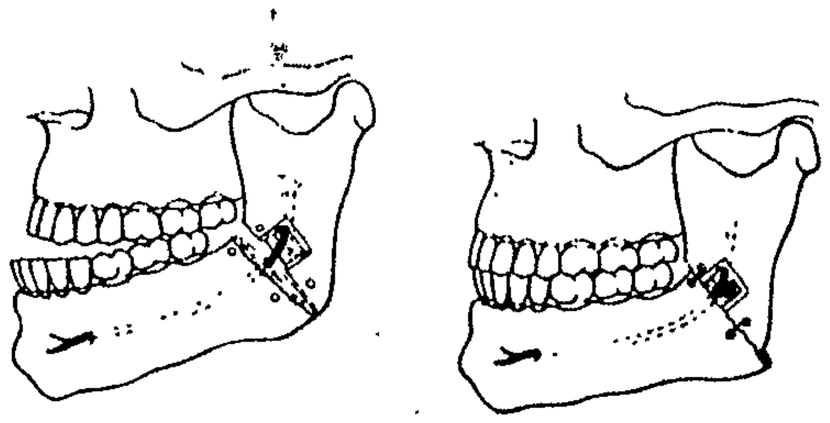


Pichler & Trauner's Inverted "L" Ramus Osteotomy Adapted for Correction of Apertognathia.
After Pichler & Trauner 1948.

Diagram 119

Surgery recommended the use of an angled cut near the angle specifically for the correction of skeletal open bite. See **diagram 118.** The procedure was a blind external approach using a Gigli saw with the section cut almost identical to the oblique ramus procedures of Kostecka (Kostecka 1928). Th exception was that the section cut was further down the ramus as close to the angle of the mandible as the Gigli saw could be placed. Winter used his procedure for the correction of open bite deformity, unlike Kostecka who used his for the correction of prognathism. Unfortunately the relapse was often worse than the original problem, unless a posterior open bite was created (Rowe 1960). Winter again presented his procedure in 1949, but this time for the correction of prognathism. (Winter, Winter & Winter 1949).

In an attempt to avoid the high rate of relapse associated with ramus procedures adapted from the correction of

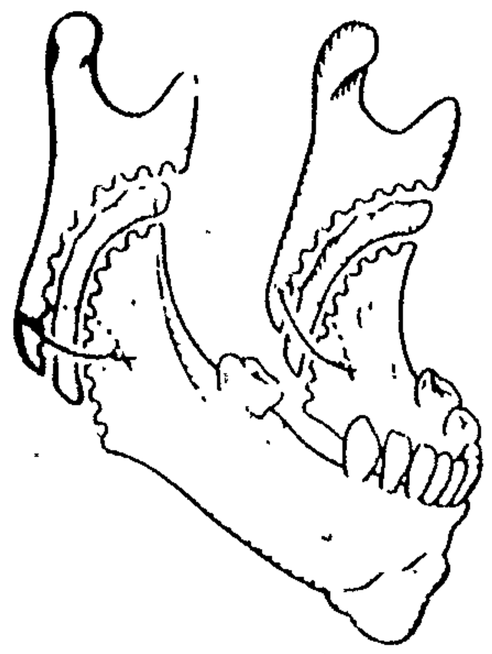


Hovell's & Pankow's Wedge
Angle Ostectomy. 1956/58.
From Rowe 1960.

Diagram 120

prognathism and retrognathism to the correction of skeletal open bites, Pichler and Trauner (Pichler & Trauner 1948) developed the "Inverted L" ramus osteotomy. See **diagram 119.** It is best suited for the correction of both retrognathia as well as open bite, where the open bite hinges on the last molar tooth/teeth. That is when there is a steep but straight mandibular occlusal plane, and there is an obtuse gonial angle (skeletal open bite). Where there is a curved mandibular occlusal plane with the plane curving about an antegonial notch and the gonial angle is almost normal (non-skeletal open bite), then this procedure, as are all ramus procedures, is contra-indicated.

The indications for the "Inverted L" procedure as mentioned above were laid down by Hovell (Hovell 1956) and Pankow (Pankow 1958). They both added as a third condition that the open bite should be extreme. Both authors were in favour of the use of

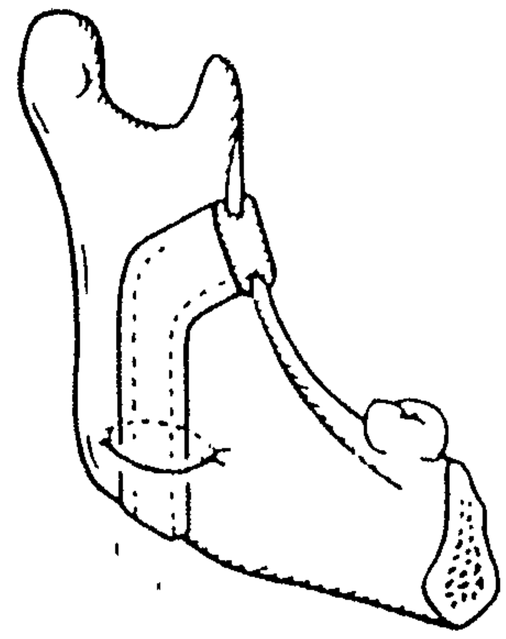


Immenkamp's Ramus Osteotomy with
Interposed Grafts.
After Immenkamp 1957.

Diagram 121

ramus procedures with these indications despite the previous poor showing of ramus procedures for the correction of open bites, with the exception of Pichler and Trauner's procedure. Where there was an extremely obtuse gonial angle, with a steeply descending mandibular plane, both authors, Hovell & Pankow, recommended that an ostectomy at the angle was indicated. See **diagram 120.** The procedure required a wedge section of the mandible from the retromolar region to the angle of the mandible. The large end of the wedge at the anterior retromolar area of the angle and the thin end of the wedge at the gonial, posterior area of the angle. A small box was cut into the superior (ramus) fragment to place and protect the mandibular nerve, which was not cut. The approach used was a submandibular external incision at the angle approximately two inches long. There were no reports following up this procedure.

Bell (Bell 1971) recommended the "Inverted "L"



Schuchardt's Inverted L Ramus Osteotomy with interposed Graft, After Schuchardt 1961.

Diagram 122

procedure for the correction of moderate to severe skeletal open bite when only the molar teeth occlude. A bone graft was recommended where the open bite was severe, and where the deformity is compounded by a vertical enlargement of the symphysis, then a reduction genioplasty should be carried out using the bone to either augment the chin (or the ramus osteotomy).

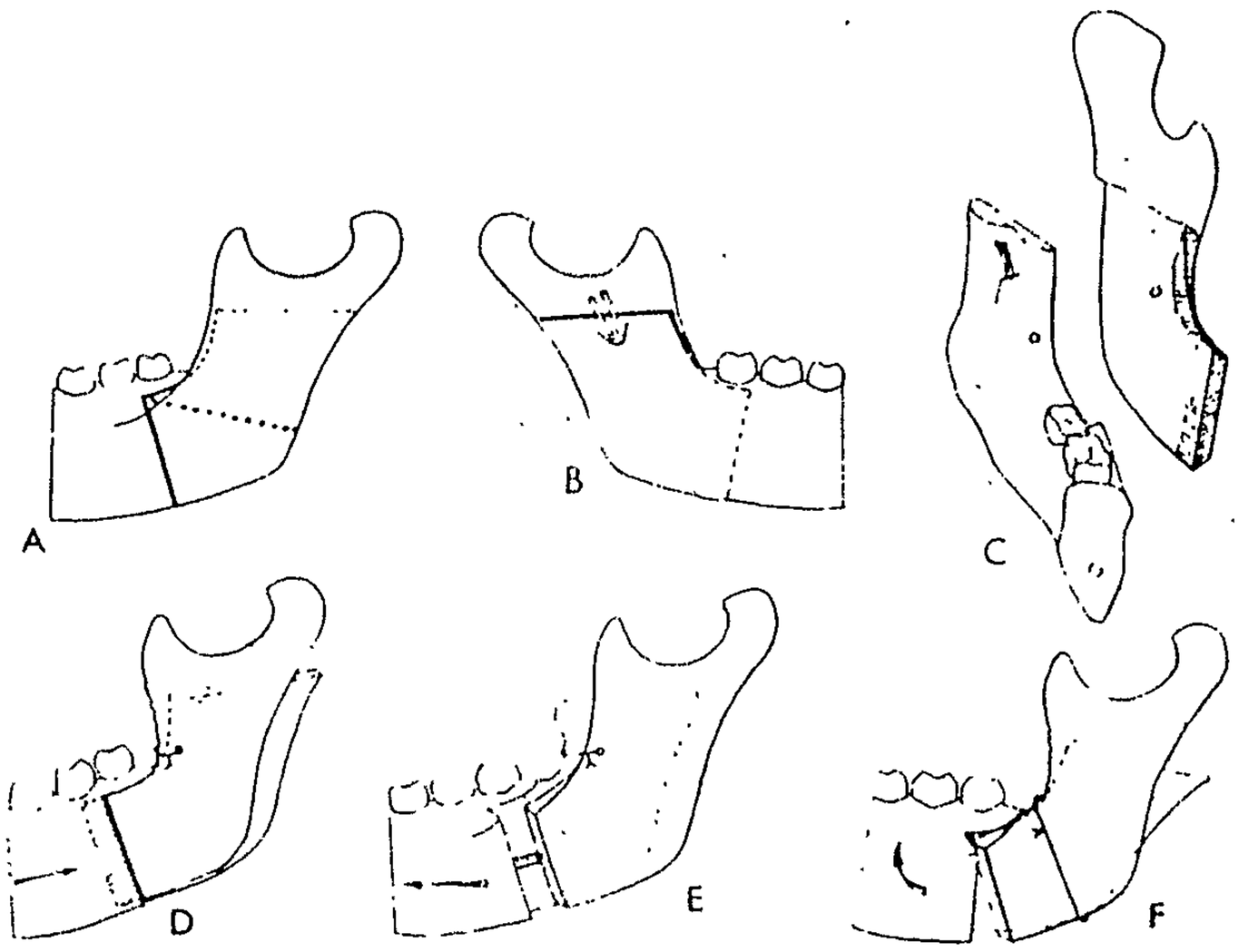
Immenkamp (Immenkamp 1957) reported a variation on the "Inverted L" and Cryer's curved section at the angle. He used the starting and finishing points of the "Inverted L", but cut a curved section instead of a sharper "L" shape. See **diagram 121.** Schuchardt (Schuchardt 1961) used Immenkamp's procedure for the correction of several cases of retrognathia with extreme skeletal/posterior open bite. Schuchardt achieved this by adding a costal graft to the section site to make up the deficiency by protruding and closing the mandible. See **diagram 122.** The mandibular neurovascular bundle remained intact. Hinds and Kent

(Hinds & Kent 1968, 1972) recommended the Inverted "L" procedure for the correction of skeletal open bite deformity as having most of the advantages of the sagittal split procedures and also being able to change the gonial angle, where they felt this to be an important consideration. While the sagittal split procedure was acceptable, Hinds and Kent felt that the vertical subsigmoid procedure was not suitable for the correction of open bite deformity due to the high rate of relapse. Most open bite deformities they felt were best corrected either in the maxilla or by combination of maxillary and mandibular procedures.

Shira (Shira 1961) reported the use of a sliding vertical osteotomy of the ramus, for the correction of a skeletal/posterior open bite, decorticating the ramus as reported by Caldwell and Letterman (Caldwell & Letterman 1954) to obtain maximum union. Shira recommended the procedure on the same grounds that Hovell and Pankow, and later Lines & Steinhäuser did, who all recommended ramus procedures for the correction of open bite deformity.

Hammer (Hammer 1972) reported one of the earliest and few recorded cases of correction of skeletal open bite on an edentulous mandible. Hammer used a vertical oblique subsigmoid osteotomy to correct an open bite deformity that would not allow the construction of adequate dentures. The procedure could be used with or without a coronoidectomy depending on the degree of open bite that required correction. Hammer reported satisfactory success.

Obwegeser (Obwegeser 1964a+b) wrote specifically on indications for the use of the sagittal split procedure, recommending



Obwegeser's sagittal splitting technique of the ramus (a-c) for correction of mandibular prognathism (d), retrusion (e), and open bite (f).

Obwegeser's Modified Sagittal Split Osteotomy of the Ramus for Correction of Apertognathia, amongst other Deformities.
From Obwegeser 1964.

Diagram 123

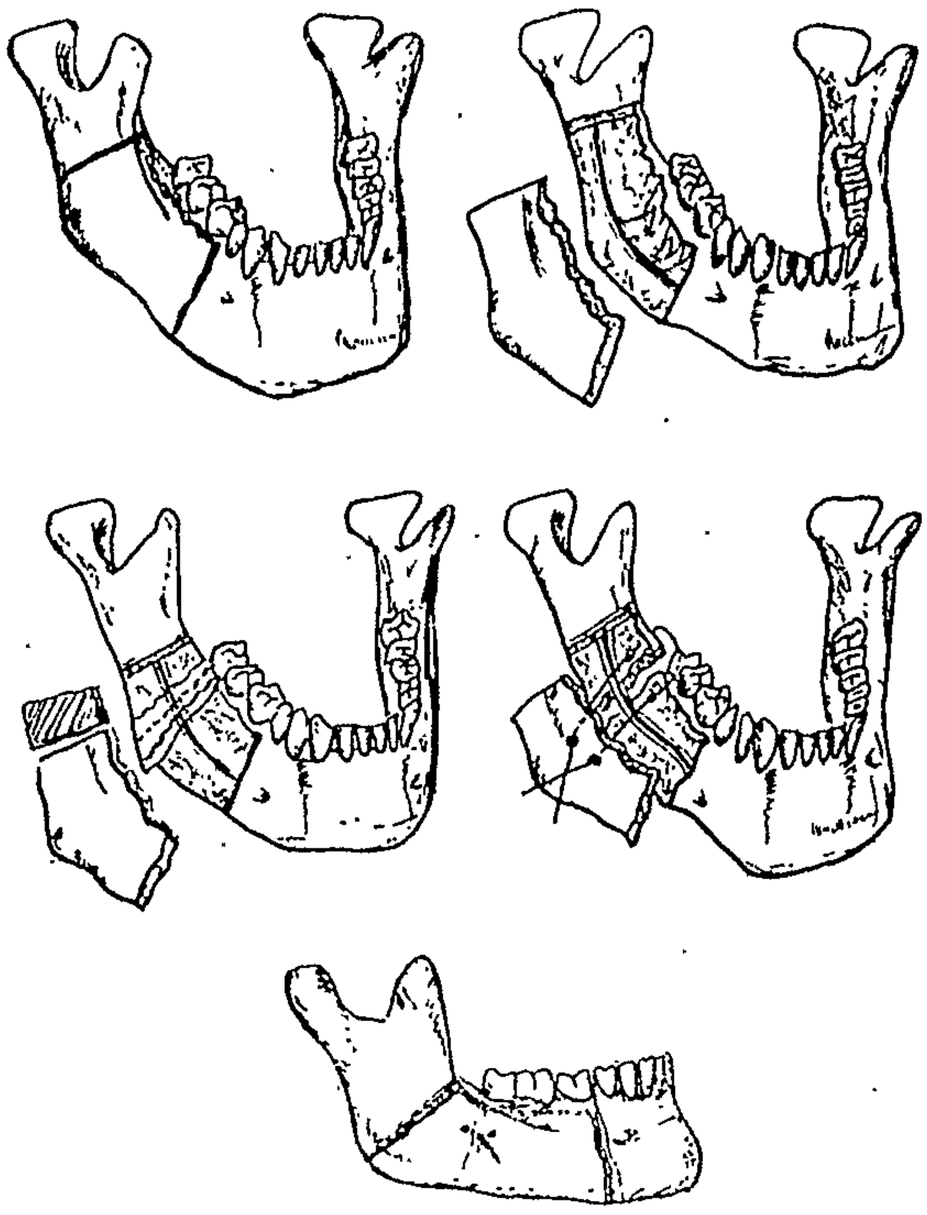
the use of the ramus sagittal split procedure for the correction of skeletal open bite deformity where the open bite is confined to the molar region, where the mandibular occlusal plane is straight and where the open bite was not too extreme anteriorly. See **diagram 123** and demonstrated in **Illustration 8.**

McNeill, (McNeill 1973) while recommending the sagittal split osteotomy for the correction of skeletal open bite, did concede that there were post-operative problems with the technique and recommended that overcorrection be obtained and temporarily held using an acrylic gag on the posterior teeth to

Correction of Apertognathia Using Sagittal

Split Ramus Osteotomy After Obwegeser

Illustration 8



Obwegeser's Modified Sagittal Split Ramus Osteotomy for the Correction of Prognathism (Shown) and Recommended for the Correction of Apertognathism. From Obwegeser 1964.

Diagram 124

maintain a temporary posterior open bite that was slowly allowed to correct itself. Furthermore he recommended the use of a skeletal brace such as a head-chin cap or chin-shoulder brace to maintain a positive pressure on the corrected open bite.

Obwegeser wrote of a modification to the sagittal split procedure specifically for the correction of skeletal open bite deformity with severe prognathism. The reason for the modification was insufficient bony contact when the mandible is retruded more than

and then rotated for the correction of apertognathia at the same time. (Obwegeser 1964)

Obwegeser's modified technique required the removal of the lateral cortical bone from a lateral cut in the ramus well above the angle of the mandible, to a vertical cut in the body of the mandible. The remaining lingual bone, still containing the neurovascular bundle, was sectioned at the angle, and sufficient bone removed to allow for the required amount of retrusion and rotation to correct the severe prognathism and accompanying apertognathia. The bundle was carefully dissected free prior to sectioning. When the mandible was satisfactorily reset, and the lateral cortical plate also adjusted to fit back into its lateral position, the lateral plate was wired to both the anterior and posterior lingual fragments, either side of the lingual cut. The diagram shown from Obwegeser's article only demonstrates the procedure used for the correction of prognathism, but was adaptable and indicated for the correction of apertognathism. See **diagram 124.** Thus a far broader surface of bony contact was obtained than the conventional sagittal split procedure would have obtained. The procedure was performed entirely intra-orally using the same incision and instrumentation of the conventional sagittal split procedure. (Obwegeser 1964)

Obwegeser's modified procedure was tried and reported by Takahashi and Tsuruki (Takahashi & Tsuruki 1980) who also did a partial glossectomy prior to the osteotomy as a first stage procedure as macroglossia was diagnosed and considered to be a potential source of relapse. The authors were pleased with the results, in particular commenting on the improvement to the gonial angle, but they did note that the procedure was difficult to perform,

but no details as to why the procedure was difficult were given.

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APERTOGNATHISM

Adjunct Procedures.

Myotomies.

Blair (Blair . 1915) noted that he had some difficulty with the tongue when he performed his "V" shaped section because of the shortening of the mandibular arch perimeter and therefore crowding of the tongue. He further noted that the tongue was often large to begin with. Blair introduced a vertical body cut to help counter the decreased space for the tongue and at the same time correct the open bite deficiency by sliding the anterior fragment superiorly. Both procedures were for the correction of anterior open bite where there was no other substantial deformity such as prognathism which may often present with open bite deformity. Blair was pessimistic about the future success of the procedures for the correction of open bite due to subsequent muscle pull on the anterior fragment when fixation was removed. He referred to the geniohyoid and digastric muscles in particular. In order to help stop or decrease this muscle action, Blair advocated head-chin cap fixation and for long periods.

The role of the tongue in relapse has not been fully established. There are surgeons who feel that partial glossectomy or even a deep lingual frenectomy (where there is too much anterior tongue functional activity caused by restriction of the tongue by a lingual frenum) is a requirement for prevention of relapse to a significant degree. Nordenram and Olow-Nordenram demonstrated that there is doubt and there are many contradictory opinions. They showed that relapse has occured with partial

glossectomy, and that the tongue has been reported as returning to the original size post-operatively without significant relapse. There have also been reports of the beneficial effects of glossectomy on the prevention of relapse. Hence there is considerable confusion regarding the desirability of the procedure. (Nordenram & Olow-Nordenram 1966; Olow-Nordenram & Nordenram 1973).

The sectioning of the hyoid muscle group and the digastric muscle as an aid to retention have been advocated. There is much to show that they have been significant but not completely successful. Hinds and Kent (Hinds & Kent 1972) advise careful post-operative follow-up to determine whether muscle sectioning is required. They were of the opinion that muscle sectioning and glossectomy should not be performed as a pre-operative preventive measure. However examination of tongue procedures; indications, contra-indications, advantages and disadvantages, is not within the scope of this treatise nor is any detailed discussion on supplementary procedures not performed on the mandible.

Relapse Aids.

McNeill (McNeill 1973) demonstrated the problems of relapse when he suggested two sets of surgical aids. Firstly the need for long term surgical support and retention with the use of either head-chin caps or chin-shoulder braces to support the mandible. Secondly the use of acrylic wafers to give an overcorrection to the anterior open bite by creating a posterior open bite and expecting relapse to take the occlusion to normal at the end of the retention period and to help resist the relapse that is expected.

Various methods of long term retention such as shoulder braces, head chin caps, neck braces have been suggested with varying degrees of success. None have been reported as being completely successful. (James 1970).

Summary.

The subapical procedures appear at this stage to be very suitable for the correction of anterior open bite deformities, with few reports of complications at this stage, and many reports of satisfactory results. The subapical procedures have the advantage of being able to correct any chin deficiency at the same time, a common problem with anterior/non-skeletal open bite. The bone from the chin area, as a wedge, can be used to correct the open bite.

Procedures indicated for the correction of skeletal/posterior open bite deformity are generally limited to the ramus or angle of the mandible, and do not appear to be satisfactory. The procedures developed for the correction of either retrognathism or prognathism have not been completely successful. As Limberg's subcondylar procedure demonstrated, even the ramus procedures developed for the correction of skeletal/posterior open bite have often turned out to be more successful for treating other deformities. There are exceptions. The ramus "C" osteotomy while not commonly performed has been successful with minimal relapse.

Relapse is a problem that has produced a number of supplementary procedures such as myotomy of the genioid muscles in particular. Other supplementary procedures are deep lingual frenectomy or a partial tongue excision mainly where there is a decrease in the area of the floor of the mouth. Long term fixation

and subsequent retention is the treatment answer by other surgeons. Many surgeons have emphasised the need for complementary orthodontic procedures. Discussion of the supplementary procedures is not within the scope of the treatise.

Body surgery can be used to correct both types of open bite deformity. Posterior open bite can be corrected with a "C" shaped osteotomy at the angle which rotates the anterior fragment forward and upwards. Usually a graft is indicated to boost the deficient bone. Anterior open bite can be corrected with a body procedure where the body is sectioned and the anterior fragment rotated. This is useful where there is a satisfactory posterior occlusion and reversed curve of Spee.

Problems with post-operative management has been one of the reasons why maxillary procedures for the correction of open bite deformities have become popular, in some cases using only maxillary procedures to correct the problem. However this area of surgery is not part of the field of this treatise.

Management of open bite deformity whether of a skeletal or non-skeletal type is difficult. The problems are chiefly those of relapse. The number of procedures reported, current as well as past, either solely for the correction of open bite or adapted from procedures used for the correction of other deformities, indicates that treatment is far from definitive. In general, most reports would indicate that the treatment of open bite deformity is a very individual arrangement with the type and number of procedures required for a satisfactory result varying according to the case. Most cases would seem to require multiple procedures. Even to the

extent of having a combination of ramus, body and subapical procedures. The emphasis must be on careful, individual treatment planning for the needs of the patient.

oOo

MANDIBULAR ASYMMETRY

Classifications

Introduction.

There have been many attempts to make a satisfactory classification of mandibular asymmetry in part due to the lack of information on the exact nature of and variable aetiology of mandibular asymmetry. Most of the classifications of mandibular asymmetry have been based on aetiology or clinical features. Principally the latter.

Discussion.

Rushton (Rushton 1946) related the type of asymmetry to the time of growth. All asymmetries were due to condylar growth patterns only, that is condylar hyperplasia was the only aetiology. Where the hyperplasia was in childhood then there would be compensating alveolar growth and also the mandibular body, condyle and ramus would be in proportion. (Unilateral macrognathia). Where the hyperplasia commenced or extended into adulthood where there was no compensatory growth from the rest of the mandible then a disproportion of the condyle developed.

Waldron, Peterson and Waldron (Waldron, Peterson & Waldron 1946) described two types of deformities. Those with posterior open bite and anterior contact, and those with posterior contact and anterior open bite. Their patients did not appear to have condylar hyperplasia but instead a unilateral prognathic cross-bite, and therefore distinct from Rushton's asymmetrical types.

Gottlieb (Gottlieb 1951) described mandibular asymmetry as due to osteoma of the condyle when unilateral. Hinds et al (Hinds, Reid & Burch 1960) noted only two types of asymmetry; Unilateral condylar hyperplasia, and Deviational (asymmetric) prognathism. Kazanjian (Kazanjian 1928) mentioned the problem of agenesis producing asymmetry.

Rowe, (Rowe 1960) reported several groups of asymmetry:

1. Unilateral Condylar Hyperplasia.
2. Unilateral Condyle Agenesis. With or without soft tissue deficiency.
3. Unilateral Macrognathia. Bony only
4. Unilateral Macrognathia. Bony and muscle.
5. Unilateral Micrognathia.

From these groups he developed a simple classification based on clinical assessment:-

1. Unilateral protrusion.
2. Unilateral retrusion.
3. Unilateral macrognathia without gross protrusion.
4. Unilateral micrognathia without gross retrusion.

Cernea (Cernea 1967) suggested four types:

1. Laterodeviation with prognathism and open bite in the posterior region on one or both sides.
2. Laterodeviation with posterior open bite without prognathism.
3. Laterodeviation with prognathism without posterior open bite.

4. Facial asymmetry without prognathism.

Dingman & Grabb (Dingman & Grabb 1963) wrote a general review of the treatment of mandibular "laterognathism", a the term for asymmetry of the mandible regardless of aetiology. In the article Dingman and Grabb described the aetiology of mandibular asymmetry with the following classification:

A. DEVELOPMENTAL.

1. Agenesis
2. Unilateral Arrest of Growth (Condylar Hypoplasia)
3. Unilateral Overdevelopment (Condylar Hyperplasia)

B. ACQUIRED

1. Malunited Fracture of the Mandible
2. Unilateral Loss of Part of the Mandible
   - (i) Trauma (comminution)
   - (ii) Trauma (loss of part of the mandible)
   - (iii) Osteomyelitis
   - (iv) Tumour
   - (v) Operative Resection

Dingman and Grabb listed the procedures that could be used for the correction of the above types of asymmetry, and which were in their opinion most suitable for the correction of the different types of deformity:

1. Bilateral vertical osteotomy of the body with a lateral shift of the anterior fragment to correct a cross-bite asymmetry where there is no anterior-posterior deficiency. The section is placed where the cross-bite commences.

2. Excision of the condyle where the problem is a unilateral condylar hyperplasia. The excision is a unilateral resection.
3. Osteotomy of the body on the deficient side of the mandible followed by an ostectomy of the body on the hyperplastic side. The body is swung about the site of the osteotomy.
4. Where the asymmetry is moderate, the deficient side can be extended using a step section or when severe a graft can be placed as well in the site of the osteotomy in "3.", so as to lengthen the body on the deficient side as well as shorten the hyperplastic side.
5. Where the asymmetry is severe and also due to both body and condyle hyperplasia, then the use of a condylectomy as well as the procedures listed in "4."
6. The use of body recontouring either as a "shave" procedure to reduce the hyperplastic area, or by the addition of grafts to the deficient area to build it up, where the disturbance to the occlusion is minimal and the asymmetry is limited to the body and not to the condyle nor ramus. (Dingman & Grabb 1963)

Bruce and Hayward (Bruce & Hayward 1968) in a review of condylar hyperplasia and mandibular asymmetry, suggested the following classification:

1. <u>Deviation Prognathism</u>

   General prognathism combined with a particular unilateral excess growth.

2. <u>Condylar Hyperplasia</u>

   Manifested by an enlargened head or extended neck of the

condyle, or both.

3. Unilateral Mandibular Hyperplasia

Unilateral Macrognathia. With or without compensatory maxillary and mandibular dentoalveolar adaptation.

Hinds (Hinds, Reid & Burch 1960; Hinds & Kent 1972) developed a more encompassing classification:-

I. Unilateral Facial Overdevelopment.

A. Hemihypertrophy.

1. Total.

2. Segmental.

3. Crossed.

B. Mandibular hyperplasia (condylar).

C. Mandibular hypertrophy (unilateral macrognathia).

1. With muscle involvement.

2. Without muscle involvement.

D. Deviation prognathism.

E. Unilateral masseteric hypertrophy.

F. Other.

II. Unilateral facial underdevelopment.

A. Mandibular hypoplasia.

1. Condylar.

2. Facial.

B. Arrested condylar growth.

C. Condylar agenesis.

Bell et al. (Bell, Proffit & White 1980) also developed their own classification that reflected their concern for clinical conditions rather than compartmentalising problems in terms

of dimensions. Asymmetry was discussed under several headings:

A. Management of Skeletal and Occlusal Deformities of Hemifacial Microsomia.

B. The Prosthodontic Patient with the Dentofacial Deformity.

C. Maxillary Asymmetry.

D. Mandibular Excess (Unilaterally).

E. Mandibular Deficiency (Unilaterally).

Sailer (Sailer 1973) noted two cases of perimandibular Haemangiomas producing mandibular asymmetry, noting that these cases could easily be mistaken for oto-mandibular dysostosis.

Summary.

For ease of reference, the problems of mandibular asymmetry have been divided into those that are mainly condyle-based abnormalities and would require condylar surgery (with or without surgery to other areas) to correct, and those that are body/ramus abnormalities and would mainly require body and/or ramus procedures to correct. The former would usually be of an ongoing, continuing deformity due to the association of the deformity to a growth centre. The latter usually of a static nature, and therefore being a single stage growth deformity

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MANDIBULAR ASYMMETRY

Condyle procedures.

Introduction.

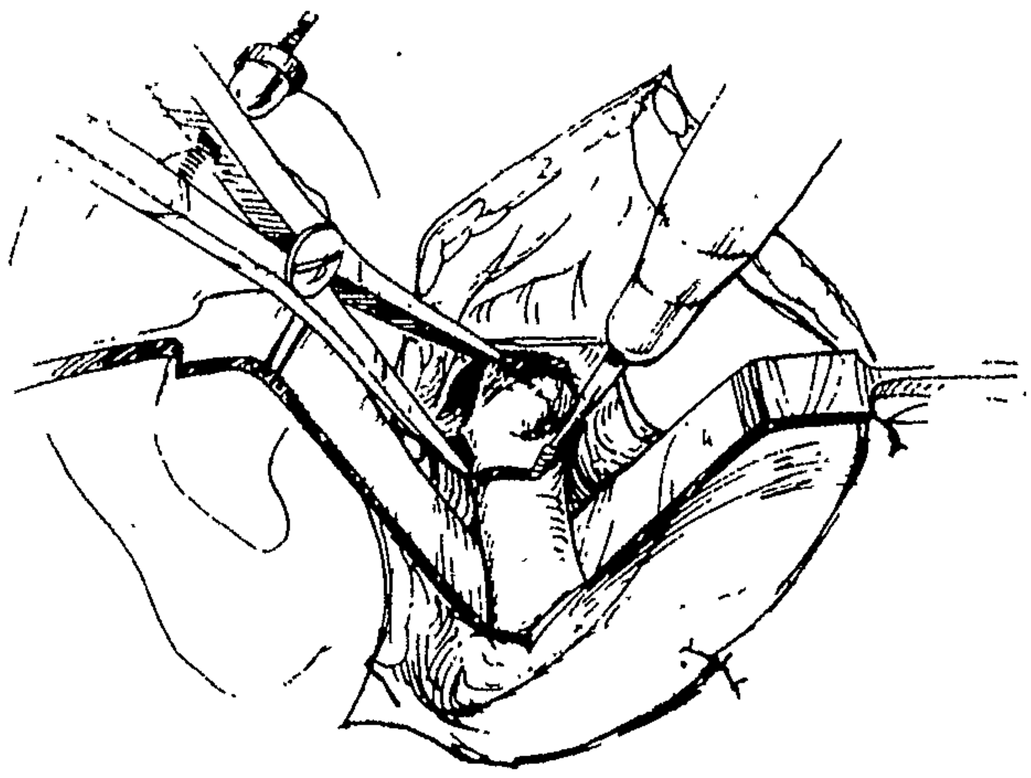
There are various reports on the types of conditions that produce facial asymmetry that relate to the condyle only. Nearly all agree that condylar hyperplasia is the most common. Epker & Wolford (Epker & Wolford 1980) are of the opinion that the general order is Hyperplasia and Osteochondroma, followed by hemifacial microsomia, ankylosis of the condyle and neoplasia (not necessarily in that order.). Norman, in reporting in a general paper on surgical diseases of the mandible, treated condylar hyperplasia as being the most important of the surgical diseases of the condyle. (Norman 1977). Norman later reported a series of 12 cases operated on over a nine year period. (Norman 1980). Norman noted that the disease was uncommon but there were no comparative figures by either Epker & Wolford or Norman on the frequency of condylar hyperplasia as the aetiology for facial asymmetry.

Use of the condylotomy procedure is not generally suitable for the correction of asymmetry, especially where the problem is that of hyperplasia or neoplasia, and hence has not been reported frequently for the correction of asymmetry.

Discussion.

Development of Condylectomy and Condylotomy Procedures.

Condyle procedures for the correction of mandibular asymmetry were first used and generally developed for the treatment of condylar hyperplasia, usually unilateral. The procedure first



CONDYLECTOMY

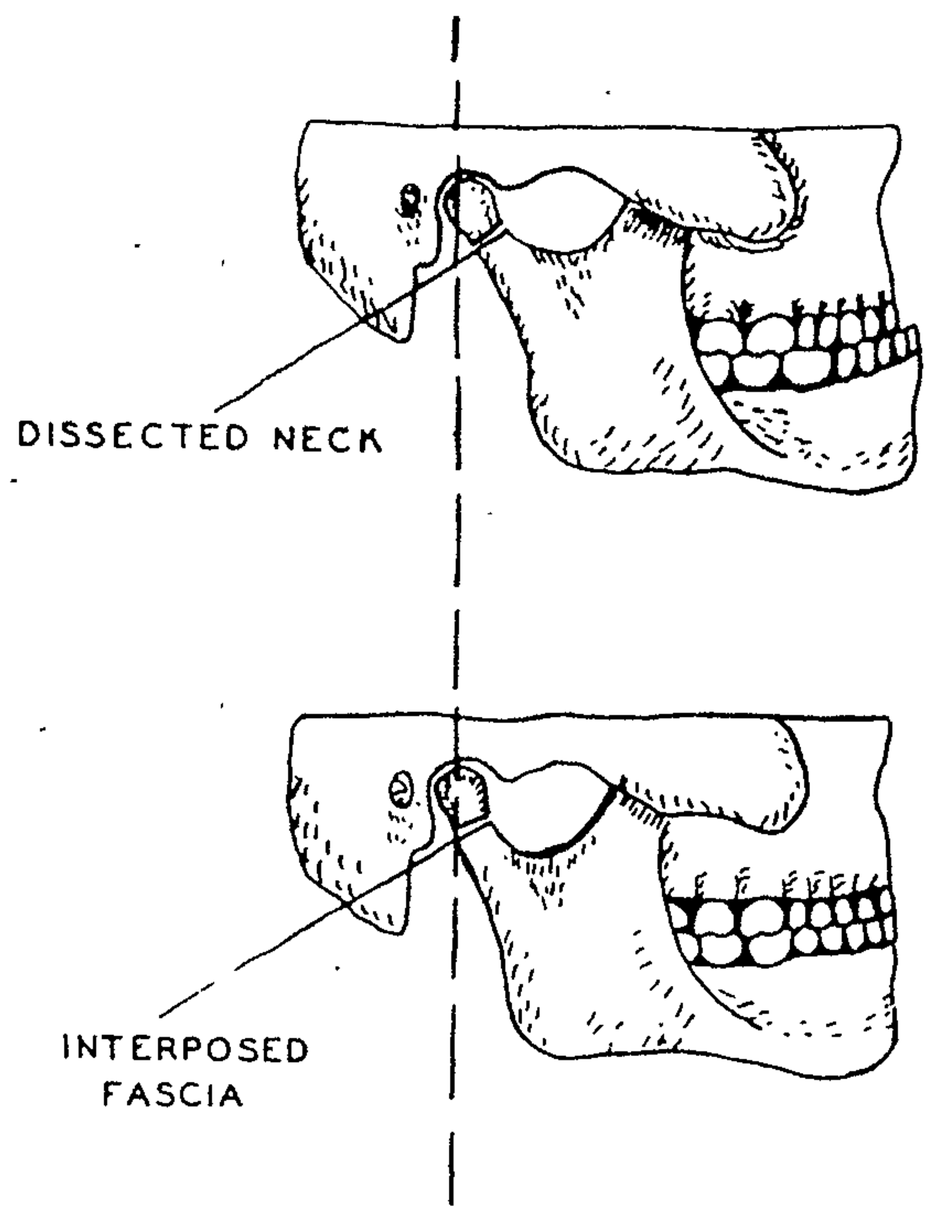
Pre-auricular Condylectomy.
From Epker & Wolford 1980.

Diagram 125

used was a condylectomy. See **diagram 125.** Unilateral hyperplasia was first reported by Adams in 1836 (Adams 1851) but not treated surgically by him. The first surgical treatment of condylar hyperplasia was by Humphery (Humphery 1856) twenty years later. Humphery claimed complete success by being able to give the patient a new mandibular position using a condylectomy procedure. The surgery, as performed by Humphery, was a blind destruction of the joint with instrumentation, via a pre-auricular incision. (Ivy 1927). This was followed by Heath (Heath 1883) and later Eckert (Eckert 1899) both of whom resected the hypertrophied condyle and reset the mandible and the occlusion more normally.

Ivy (Ivy 1927) wrote one of the earliest reviews of the treatment of condylar hyperplasia. In that review he recommended the procedure as described by Humphery, with only small variations, for the correction of asymmetry. Ivy preferred to use the same

The incision is approximately over the zygoma, the branch of the facial nerve to orbicularis oculi being below. The only scar beyond the hairline lies in a skin fold in front of the ear.



"The fascia flap grows firmly and quickly to the roughened bone ends, making a cushion that permits a sufficient "bow back" for the resumption of a normal occlusion."

Lettit & Walrath's Flail Joint Osteotomy.
From Lettit & Walrath 1917.

Diagram 126

preauricular approach. He was to change this approach to that of Risdon's approach (Risdon 1934) when he submitted a later paper in 1949. (Ivy 1949).

Gruca and Meisels (Gruca & Meisels 1926) in their review of seventeen cases emphasised the importance of early surgery.

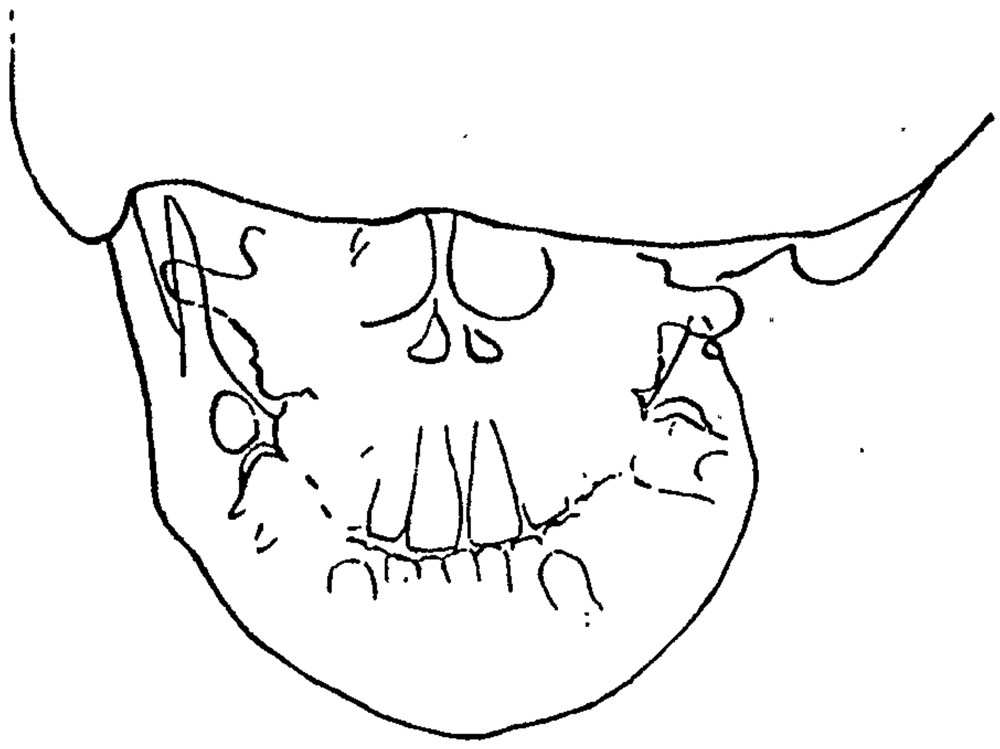
Pettit and Walrath tried to avoid the dangers of a blind approach to the condyle and at the same time create a second joint, a pseudoarthrosis, at the neck of the condyle by interposing reflected temporal fascia between the two fragments to encourage the pseudoarthrosis. The mandible was then "bent" back into position. See **diagram 126.** The approach was a pre-auricular incision (an inverted "J") followed by blunt dissection to the condyle. The condyle was sectioned just below the head partly inside the capsular ligament. The condyle head was not removed, instead the temporal fascia (as previously described) was interposed. The mandible was then rotated to correct the asymmetry. Fixation was maintained for three weeks which included a posterior occlusal gag to maintain separation of the interposed fragments. The condyle was sectioned by chisel to minimise damage to the internal maxillary artery. Pettit and Walrath performed the surgery in 1931 and reported it sixteen years later with having complete success at that date. There had been no discomfort, no instability, no impairment of function especially not of mastication, and no limitation of mouth opening. (Pettit & Walrath 1932, 1947).

This is contrary to the opinion of Smith and Robinson (Smith & Robinson 1955) who reported that the use of "Flail" joint procedures produced unnecessary joint destruction and

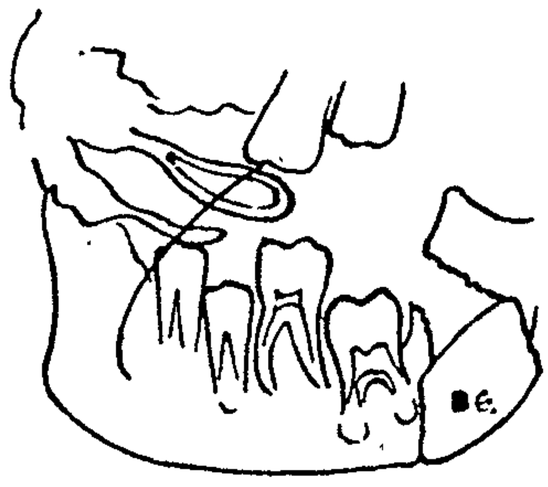
consequent limited movement due mainly to loss of lateral pterygoid function.

The lack of symptoms associated with the rotation of the condyle on the opposite side was disputed by Waldron et al. (Waldron, Karleen and Waldron 1949) who were of the opinion that rotation of the condyle on the unaffected side in the correction of asymmetry where the unaffected side is not operated on, produces Temporomandibular joint dysfunction of the unoperated side. While there were no further reports to substantiate Waldron et al. many surgeons were advocating that a bilateral procedure be performed to avoid rotation and presumably joint dysfunction. Whether the bilateral procedure was done to avoid known previous problems or only theoretical complications cannot be determined. A second perhaps more important reason for performing a bilateral procedure was to obtain a better result. Where the asymmetry has induced a contralateral effect with compensating growth on the "unaffected" side, then the "unaffected" side requires adjustment as well. A better facial appearance is obtained by adjusting both sides of the mandible, and also to obtain a better occlusion.

Rushton, in the English literature, reported a condylotomy procedure for correction of condylar agenesis. By means of a direct approach, a posterior border incision very similar to the one described by Dingman (Dingman 1944a) was made, and attachments to what was the stunted condyle were sectioned. The mandible was then wired into its new position to the maxilla. The surgeon then returned to the external wound with previously removed rib-grafts which were then wired to the ramus to assume the new altered condyle shape. See **diagram 127.** (Rushton 1942).



Tracing of radiograph showing failure of left mandibular ramus.



Rushton's Condylotomy and Graft for Correction of Condylar **Agenesis.** From Rushton 1942.

Diagram 127

In 1946 Rushton reported a series of resections used in the treatment of unilateral condylar hyperplasia and concluded that he was firmly of the opinion at that date that resection of the condyle was the procedure of choice for the correction of mandibular asymmetry caused by unilateral condylar hyperplasia. He did add that the extraction of teeth and their replacement with dentures was sometimes necessary to achieve a more balanced occlusion from surgery alone. In his report Rushton stressed the need for proper treatment planning and in particular as regards the timing of the operation. Generally speaking he noted,

the surgery should be performed as soon as possible but with due regard to:

Firstly — The confirmation of the presence of the hyperplasia.

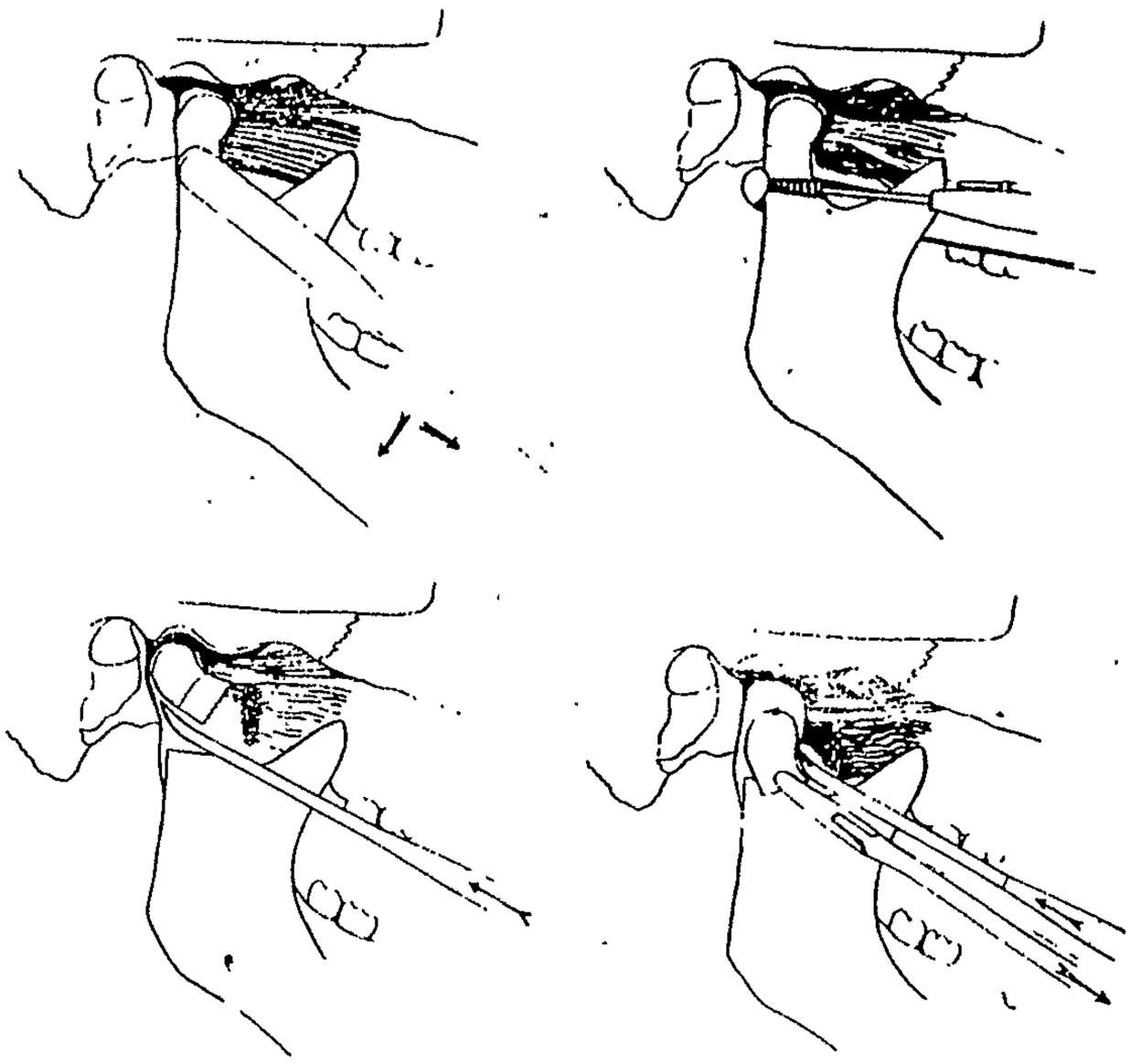
Secondly — That the correction does not leave the corrected side too short.

To the above two requirements could be added:

Thirdly — The extent to which the occlusal plane has been affected which may require a combined maxillary / mandibular procedure .

Therefore treatment planning should consist of proper diagnosis followed by an operation that would bring symmetry to the mandible. This would allow for proper development of the dentition . Rushton did not specify an age nor age range when these procedures should be performed. Rushton's surgical approach was direct and pre-auricular.

European authorities were reporting more cases of condylar hyperplasia in comparison to American surgeons, and were treating the disorder almost as a common deformity. It was not until 1951 that Gottlieb (Gottlieb 1951) realised that his large number of cases (twelve) was due to an increased demand for treatment rather than a decrease in the rarity of the deformity of which only fifty cases had been reported up to that time. This was a trend substantiated by Hinds et al. (Hinds, Reid & Burch 1960), who reported fifteen cases over a four year period, many treated by an intra-oral approach condylectomy, (see **diagram 128**); and also substantiated by other surgeons such as Sear (Sear 1972) and Norman (Norman 1977, 1980).



The operative stages of intra-oral condylectomy.

Intra-oral Condylectomy.
After Hinds, Reid & Burch 1960.

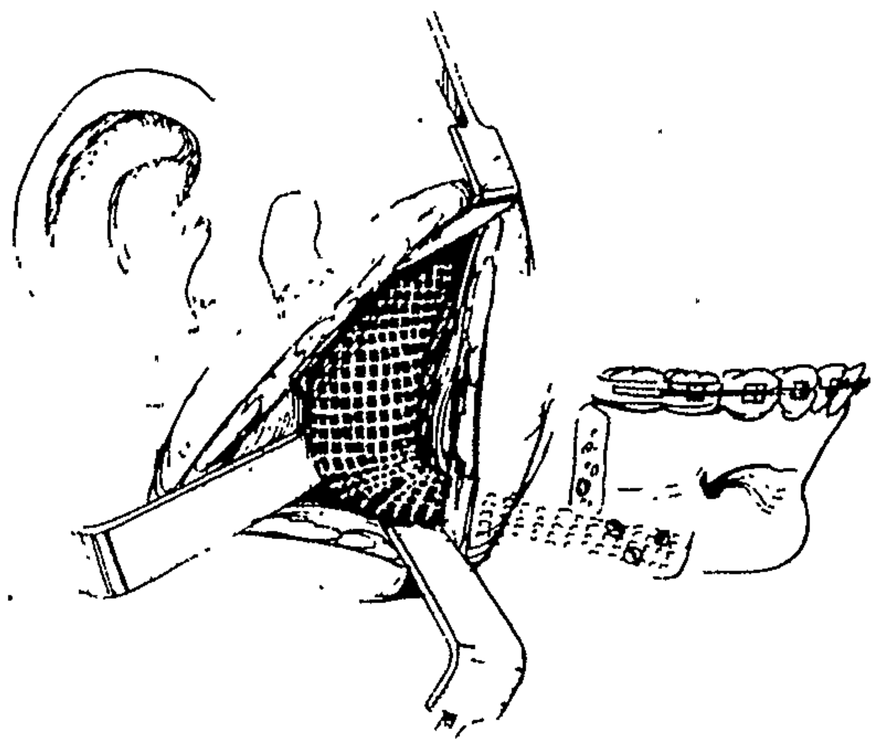
Diagram 128

The most extensive review of condylar hyperplasia and the correction of the resulting asymmetry was by Blomquist and Hogeman (Blomquist & Hogeman 1963) from the Swedish literature. They chronologically listed every report up to 1963 and examined them for treatment and result comparisons. They found a total of one hundred and two cases, and in which there was an even sex distribution. In fact Blomquist and Hogeman did miss a few reports which Bruce and Hayward (Bruce & Hayward 1968) followed up, and added cases performed between 1963 and 1968. Blomquist & Hogeman performed all of their correction procedures using a ramus procedure or a condylectomy procedure, sometimes combined with a genioplasty where the problem was severe. Bruce and Hayward's review was an excellent coverage of all aspects of the treatment of condylar hyperplasia including

techniques other than condyle techniques for the correction of the deformity.

Where the hyperplasia develops in childhood or early teens, before the pubertal growth spurt, then the deformity will usually have an affect beyond the condyle and the elongation of the ramus vertical dimension. There is as well bowing of the inferior border of the affected side, posterior open bite deformity of the affected side, a chin shift towards the normal side, and in children especially (as distinct from early teens), there can be found compensatory vertical growth of the affected side maxilla to close the posterior open bite, canting of the occlusal plane, a crossbite of the normal side, shifting of the mandibular teeth towards the affected side, and shifting of the maxillary teeth towards the normal side. (Epker & Wolford 1980).

Where the deformity commences in adulthood, there is far less compensatory growth and correction is limited more to the area of the hyperplasia, rather than requiring multiple procedures to correct secondary deformities. In such cases condylectomy still has its place. Where the deviation is limited to the chin point with an otherwise normal mandible and occlusion, the straightening genioplasty is recommended. Where there is substantial deformity of the ramus and body, and where there is a compensating deformity to the contralateral side, then ramus and/or body surgery is indicated to correct the deformity. Compensating deformity may also require surgery to the maxilla to fully correct the deformity. However this aspect of maxillary deformity is not within the context of this treatise. (Epker & Wolford 1980).



ALLOPLASTIC REPLACEMENT OF MANDIBULAR CONDYLE

From Epker & Wolford 1980.

Diagram 129

Condylectomy is indicated where the pathology is still active, and is best undertaken as soon as possible before compensatory growth occurs requiring more extensive correction. As well, condylectomy is generally indicated where:

a. there is an excessive enlargement of the condyle, in order to determine a histological diagnosis;

b. there is temperomandibular joint pain specifically related to the abnormal condyle, a problem usually related to tumours other than hyperplasia. (Epker & Wolford 1980).

When condylectomy is indicated such as for an osteochondroma or hyperplasia in a very early stage, and there is little asymmetry evident, then a bone graft or alloplastic replacement is also indicated to maintain the facial symmetry. The preferred graft is a costochondral graft or where an alloplastic replacement is to be used, the preferred replacement should have an attached condyle head with suitable meshing to attach to the ramus.

Post-operatively, when a prosthesis is used, intermittent intermaxillary elastics are used to encourage function of the new condyle. See **diagram 129.** (Epker & Wolford 1980)

Where there is no joint dysfunction and there is evidence of the arrest of the growth, then condylectomy is not indicated. In such instances other procedures of the ramus or the body are better indicated, where the aim is to produce better facial contour and occlusal function. (Epker & Wolford 1980).

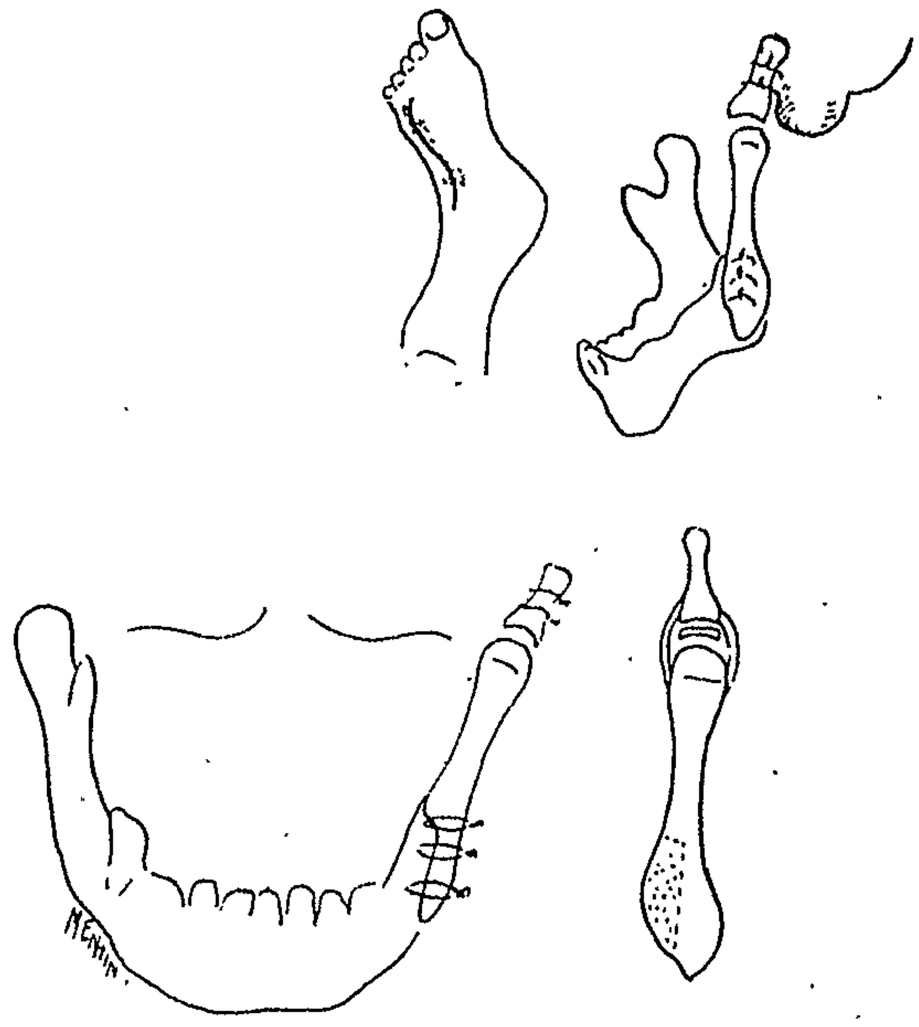
Condylar agenesis is an unusual almost rare problem that should be mentioned for completeness. However lack of material may be also be due not only to the rarity but also to a lack of suitable procedures that can correct the problem adequately.

Hovell (Hovell 1960) and Osborne (Osborne 1964) were amongst the first to report on the treatment for the correction of condylar arrest and condylar agenesis. Both surgeons recommended ramus procedures and will be discussed in the section on ramus procedures.

<u>Development of Grafting (including Growth Centre) Procedures</u>.

Robinson (Robinson 1970) reported operating on two of a total of six cases of condylar agenesis that he presented. Robinson used a vertical sliding osteotomy on the uninvolved side, and a rib graft on the deficient side to take the place of the condyle head and to boost the ramus.

Kazanjian (Kazanjian 1939) had previously recommended in his five cases that any bone grafting procedures to the affected side in cases of condyle hyperplasia be delayed until



Entin's Use of a Metatarsal Phalangeal Joint to Rebuild the Condylar Joint as a Growth Centre. From Entin 1958.

Diagram 130

maturity (of the bony structures). Since then there has been a change of thinking, and it is now recommended that correction of condyle abnormalities be performed at an early age to decrease compensatory growth effects in other areas. One of the first to advocate early surgery was Rushton (Rushton 1946) who advocated early surgery for condyle hyperplasia, as soon as the deformity is discovered, but with regard to certain factors previously listed.

One of the first reports of the transplantation of a growth centre was from Stuteville and Lanfranchi (Stuteville & Lanfranchi 1955) who used the head of a metatarsal bone. This was followed by Sarnat and Robinson (Sarnat & Robinson 1956) who recommended the use of a costochondral graft, and later Entin (Entin

1958) who reported using a metatarsal phalangeal joint to rebuild the condyle. See **diagram 130.**

Ware (Ware 1970) recommended the use of the costochondral graft as being the most satisfactory of the grafts. It was Ware's opinion that the use of the growth centre transplantation was better indicated for cases of ankylosis deformity than for agenesis, as decreased mobility usually resulted when the procedure was used for the correction of agenesis.

Epker & Wolford recommended that for the growing patient a bone graft growth centre transplantation be performed. The recommended graft was an autogeneous costochondral rib graft. One centimetre of cartilage with several centimetres of rib bone was recommended. The graft was attached with the cartilage part against the what is remaining of the glenoid fossa, or the nearest site thereof, and the remainder of the rib wired to the ramus. Where there is little or no anatomical ramus then further rib grafting may be necessary. It was also recommended that the graft or grafts be drilled for the depth of the cortex only to decrease revascularisation and decrease healing time. See **diagram 131.** (Epker & Wolford 1980).

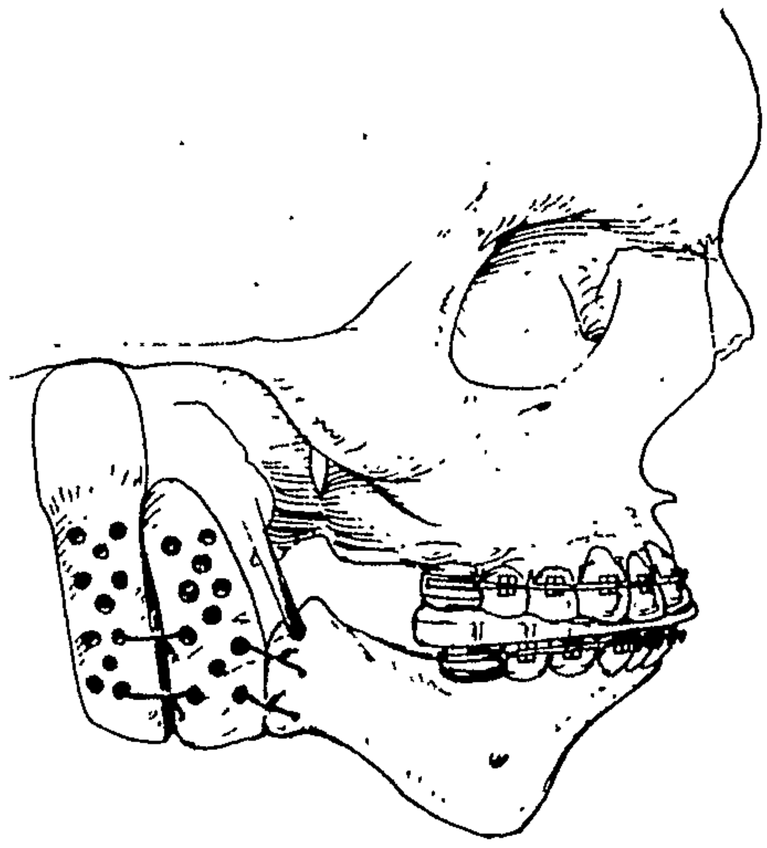
The indications for the use of growth centre transplantation were:

a. Condyle agenesis;

b. Condyle ankylosis (where there is significant facial asymmetry);

c. Condyle neoplasia;

(Epker & Wolford 1980).



**GROWTH CENTER
TRANSPLANTATION**

Epker & Wolford's Growth Centre Transplantation.
From Epker & Wolford 1980.

Diagram 131

Any residual soft tissue and bony deficiencies were best left until after puberty before correcting.

Summary.

Diagnosis of where the deformity lies is very important to treatment planning as not all asymmetries are amenable to condyle surgery. (Bruce & Hayward 1968). Generally speaking condylar procedures are best suited to correct those cases of mandibular asymmetry that are mild to moderate with a normal gonial angle. Where the aetiology is that of condylar hyperplasia then the indications for condylectomy alone are mild to moderate mandibular asymmetry and normal gonial angles. There should be little or no other deformity. But this is not always the case and the treatment

plan depends on what age the condylar hyperplasia (or other similarly acting tumour of the condyle) commences.

Where the hyperplasia develops in childhood or early teens, before the pubertal growth spurt, then the deformity will usually have an affect beyond the condyle and the elongation of the ramus vertical dimension. Multiple procedures which may or may not include the condyle are then indicated.

Where the hyperplasia commences in adulthood indications are for fewer procedures limited to the areas affected. This because the deformity is usually noted earlier. In such cases condylectomy alone is often indicated. Where there is substantial deformity of the ramus and body, and the less unlikely event of compensating deformity to the contralateral side, then ramus and/or body surgery is indicated to correct the deformity both contralateral and ipsilateral. There may be a requirement for surgery to the maxilla to fully correct the deformity. This is not within the context of this treatise.

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MANDIBULAR ASYMMETRY

Ramus and Body Procedures

Introduction.

Where the deformity affects the ramus and/or body of the mandible, then the type and number of procedures will depend on the extent of the deformity. Initially, and on the severe cases, the procedures performed were either on the affected side, and major in nature; or bilateral and also major in nature. With time, procedures were developed that were less drastic and more effective for deformities that were less than severe. The newer procedures were contouring operations that reshaped the affected part and did not require major resiting of the deformed part. The procedures could be used in combination.

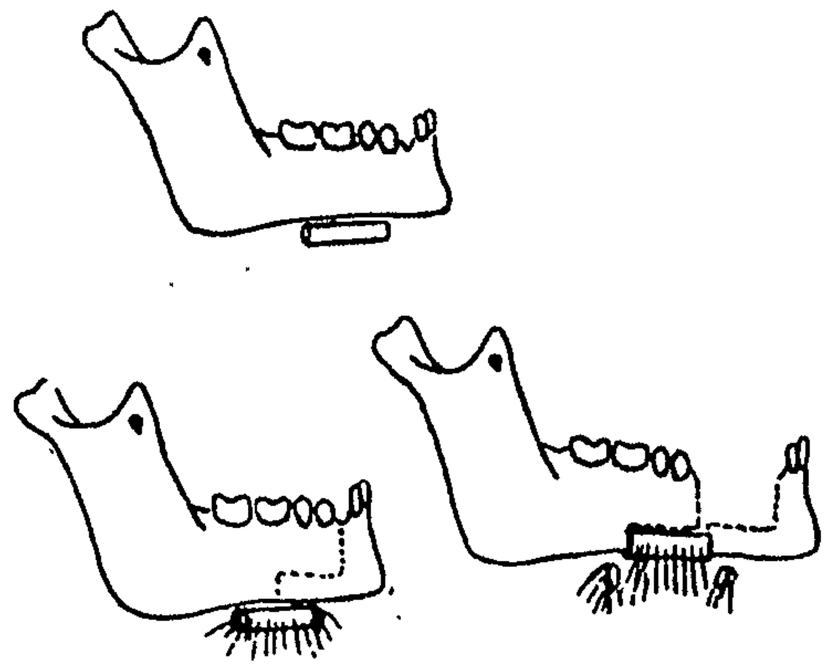
Many authors do not classify ramus and body procedures separately for the correction of asymmetry when reviewing mandibular surgical procedures, with the general exception of genioplasty procedures. This is because the ramus and body procedures are usually already covered in previous discussions of other deformities; as they were usually developed for the correction of these other deformities and not for asymmetry. (Epker & Wolford 1980, Bell, Proffit & White 1980).

Discussion.

Development of Unilateral Mandibular Underdevelopment Procedures.

I. Unilateral Autogenous Augmentation of the Body.

Limberg (Limberg 1928) reported a lengthening procedure for the correction of asymmetry through the unilateral



Case in which a steplike osteotomy permitted use of a pedunculated bone graft.

Limberg's Step Body Osteotomy with Sub-periosteal Graft.
From Limberg 1928.

Diagram 132

lengthening of the body of the mandible to achieve asymmetry. The procedure (as briefly mentioned in the chapter Retrognathism (Body Procedures) was a two stage procedure. See **diagram 132.** The first stage was the placement of a rib graft against the lower border of the mandible at the predetermined site of the of the lengthening. Approximately four to six weeks later, the surgery site was exposed and the body osteotomy cuts were placed. The section was a step section commencing at the canine region and proceeding downwards vertically for approximately one and a half centimetres, and then horizontally backwards to the molar region, and then vertically down to the lower border. The body was then expanded at the site of the surgery and the rib graft with the attached periosteum was placed into the section gap. The rib had an excellent chance of "taking" because of the already attached blood supply through the pedunculated periosteal attachment. Limberg adapted his procedure after his experiences with Pehr Gadd's (Pehr Gadd 1906) procedure for lengthening the mandible. The procedure often had an intermediate stage where traction was placed on a previously sectioned body. At

the time of the placement of the rib graft, the osteotomy cuts were placed but the body was not lengthened. Instead the mandible was placed under traction to lengthen the parts. The mandible was re-exposed as a third stage procedure, at which time the mandible was fully lengthened and the rib graft replaced into the gap. The procedures were undertaken entirely through extra-oral approaches. The grafts were never wired in as Limberg felt that this would lead to osteitis or worse osteomyelitis.

Contouring operations were developed to avoid the unsuitability of the major procedures to correct what were essentially local excess or deficient problems. Contouring operations were of two types. Those procedures that reduced the enlarged side of the mandible, and those that bolstered the deficient side of the mandible. These operations do not affect the occlusion and are therefore best suited where:

(a) the asymmetries have not affected the occlusion to any substantial degree;

(b) asymmetries are quite localised in their abnormality;

(c) or where the procedures are to be used in combination with other procedures that are to reset the occlusion.

Such other procedures would probably need to involve the maxilla and are therefore beyond the scope of this treatise.

Waldron and Risdon (Waldron & Risdon 1920) had recommended the use of iliac crest grafts to fill in the areas of bone deficiency where the problem is a unilateral hypoplastic mandible producing the deficiency rather than a hyperplastic mandible producing a unilateral excess. This technique is also suitable where the asymmetry deformity is acquired such as from trauma, rather than

developmental. Using an approach similar to the one described by Risdon (Risdon 1934) the site of the bone deficiency was freshened, and the iliac crest graft placed in the bony gap. There was no requirement to advance or retrude the body in the cases that the authors mentioned, as the asymmetry was local only.

Where malocclusion is minimal and the facial deformity is more severe, then the use of onlays alone was recommended by Converse (Converse 1950). Converse recommended the use of iliac crest bone to graft the affected area. For example where the symphysis was deficient. Converse recommended the oral approach with the base of the flap against the gingiva and the flap extending into the lip. The symphysis was exposed and the graft added and if necessary, i.e. the graft was unstable, the graft was wired to the symphysis.

In 1957 Longacre and DeStefano (Longacre & DeStefano 1957) recommended the use of split rib grafts to restore not only symphysis, but any part of the mandible that was affected. The case that they cited was for the correction of Romberg Hemi Atrophy (hemiatrophy along the distribution of the 5th. Cranial Nerve; Blakiston 1956). The grafts were introduced extra-orally and wired to the defective part of the body of the mandible laterally. They added the proviso that the grafts are suitable where the occlusion has minimal disturbance only. (Longacre, DeStefano & Holmstrand 1961).

Obwegeser (Obwegeser 1974) preferred to make great use of combining grafting of split rib grafts or lyophylised rehydrated bank cartilage as onlays to achieve desired recontouring

of deficient areas, along with concomitent correction of the normal or enlarged areas. Obwegeser's report concerned itself primarily with the correction of hypoplasias associated with Oto-Mandibular Dysostosis and not with hyerplasia. Obwegeser's article was extensive in its discussion of then current procedures, stressing treatment planning and the need for flexibility of procedures to suit the problem. Obwegeser emphasised the requirement for multiple operations in patients with problems such as Oto-Mandibular Dysostosis, quoting Pichler's axiom (Pichler & Trauner 1948): "first the bone, then the soft tissues". The aim, according to Obwegeser, was to reconstruct the different areas of the skeleton as exactly as possible to the normal. Consequently as much of the reconstruction as possible was left until the facial skeleton has reached maturity.

Obwegeser did point out that with such extensive grafting, infection and consequent destruction of the reconstructed area can ensue, a complication which did happen with one of Obwegeser's cases.

Holland and Lendrum (Holland & Lendrum 1978) made use of a pedicled clavicular graft with the sternocleidomastoid muscle still attached as the pedicle. This procedure was performed in a case where there were a number of failures of conventional rib grafts to restore an acquired deformity - an avulsed mandibular body. Insufficient local blood supply to the area made conventional grafting useless and a graft with its own supply was required. The procedure was reported as very successful and allowed later additional grafting to restore adequate contour.

II. Alloplastic Augmentation of the Body & Ramus.

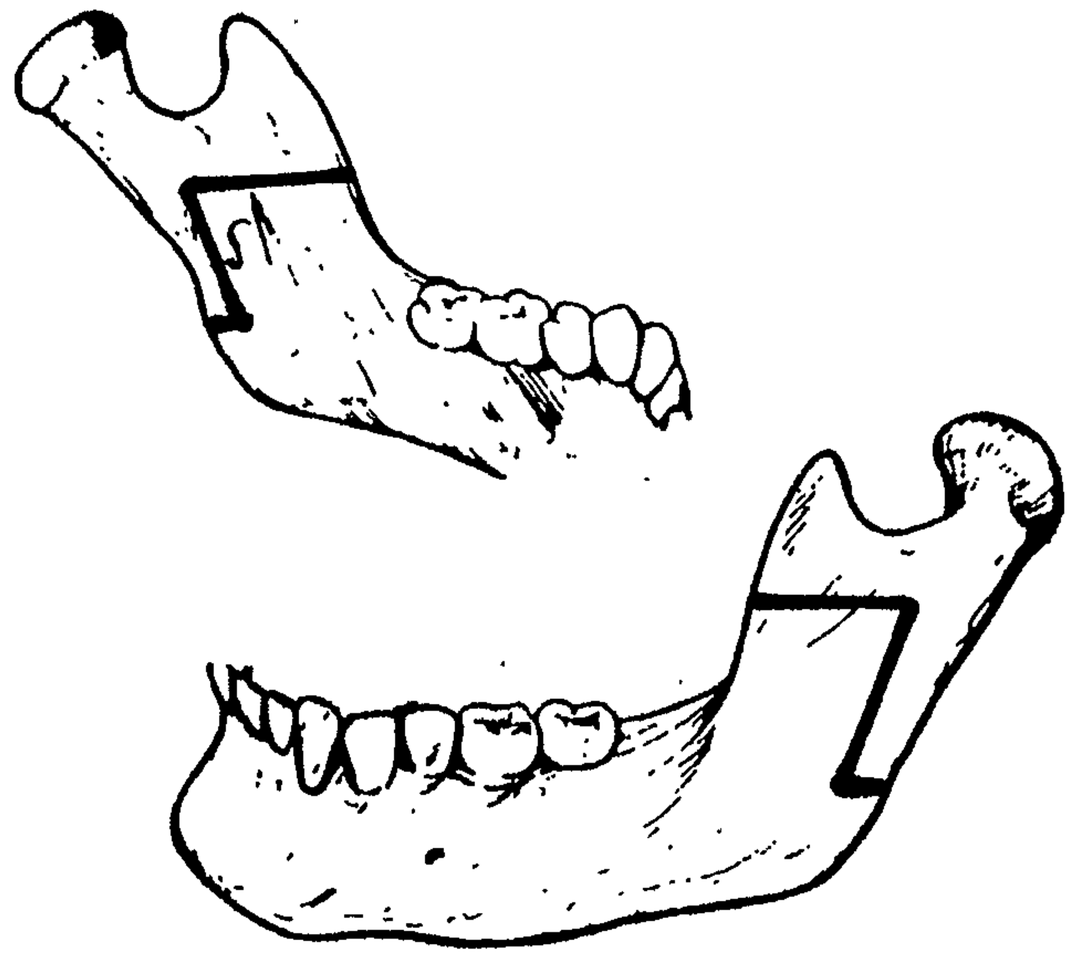
Tuinzing and Swart (Tuinzing & Swart 1981) recommended the use of an alloplastic composite material related to chemically to bone - hydroxylapatite, [$Ca_5(PO_4)_3OH$]. The use of the material in conjunction with mandibular osteotomy was described. The material had been previously reported by Swart and Groot, (Swart & Groot 1980) as a general implant material. Tuinzing and Swart described four groups of alloplastic materials:-

1. Metals.
2. Polymers.
3. Ceramics.
4. Composite materials.

Tuinzing and Swart's material was from the last group. They noted that their material was neither rejected nor encapsulated and that newly formed bone was laid down directly upon the implant material and formed a strong chemical bond with it. Further the material was bio-degradable and became replaced by the bone that grew through the material.

There continues to be an interest in finding a replacement for bone. The use of bone, especially autograft bone, does have several disadvantages.

1. The need to perform surgery on an extra site to obtain the graft.
2. The possibility of complications with the donor site.
3. Lengthening and complicating the surgical procedure
4. Possible resorption of the grafted bone, producing a result poorer than required and possibly worse than the original defect.



Tuinzing & Swart's "Z" Osteotomy of the Ramus. 1981.

Diagram 133

III. Bilateral Ramus Procedures with/out Augmentation.

Tuinzing and Swart used the material in place of a bone graft to fill in the bone gap made after the osteotomy produced the desired new shape. The enlarged side of the mandible was treated by sectioning the ramus with a vertical sliding sub-sigmoid osteotomy. The forshortened side was treated by a "Z" osteotomy, an adaptation of a procedure by Pichler and Trauner (Pichler & Trauner 1948), and also Limberg (Limberg 1925). Tuinzing and Swart sought to avoid the problems of relapse due to Temporalis muscle repositioning with Limberg's procedure, and avoid the aesthetic disadvantage of the lack of gonial angle definition. The "Z" procedure commenced with Pichler-Trauner procedure's horizontal ramus cut from the anterior border of the ramus to a point posterior to the lingula. The section then proceeded inferiorly towards the gonial angle as per the Pichler-Trauner procedure. However when a few centimetres short of the angle, the section then is taken posteriorly in the manner of the Limberg procedure. Thus the position of the Temporalis muscle is

substantially unchanged and the gonial angle is left intact. See **diagram 133.** The short term results from the combination of "Z" osteotomy, alloplastic implant and contra-lateral vertical sliding osteotomy appear to be very satisfactory.

In unilateral hypoplasia of the ramus of the young growing patient, Bell et al (Bell, Proffit & White 1980) recommended that the deformity be corrected with a vertical overlapping subsigmoid procedure on the contralateral side, and on the affected side:

a. a sagittal split procedure for moderate hypoplasia,

b. or a "Reverse L" procedure with grafting for more severe hypoplasia,

c. or a costochondral graft where there is complete lack of a ramus.

Bell et al preferred to obtain correction of the mandible, using an acrylic splint to retain a posterior open bite if necessary, before correcting any maxillary defect as a separate procedure at another time.

Unilateral hypoplasia of the ramus in the adult is corrected by means of a modified sagittal split procedure on the affected side and a normal sagittal split procedure on the contralateral side, and completing the required contour of the body by the use of bone grafts and the required contour of the chin with a horizontal body osteotomy. Bell et al preferred the use of autogenous iliac crest or rib to achieve the contouring. At the same time any maxillary procedure required was performed. The latter (maxillary procedure) is often not required in children as compensating maxillary growth may not have taken place. To obtain access to the body for any procedures, Bell et al recommended an oral

approach, placing their incision on the labial surface of the vestibule and not the alveolar side, basing the flap on the gingiva. To obtain access to the ramus and the condyle area, Bell et al recommended a pre-auricular incision, rather than a submandibular approach, although for augmentation of the lateral aspect of the ramus, an oral approach can sometimes suffice. This approach was neither recommended nor disapproved.

IV. Unusual Unilateral Hypoplasias.

Davis (Davis 1950) had previously reported a rare case of mandibular medial cleft, which in his reported case also had a cleft of the lower lip associated with the bony cleft. Davis noted that only six previous cases were reported. Davis unsuccessfully treated the patient by freeing the contractions of the cleft to the neck and then wiring the ends of the mandible together with freshening of the bony margins. The contractions regretably returned and the bony margins drifted apart, although not to the same degree as before.

Hovell (Hovell 1960) and Osborne (Osborne 1964) were amongst the first (Rushton 1942 being even earlier) to report on another rare problem, that of condyle agenesis and condyle arrest. Both surgeons recommended that a bone graft be wired to the ramus to bolster both the ramus, which is usually deficient, and to substitute for the condyle. Where there was ankylosis of the joint, then Hovell recommended that the correction of the ankylosis be performed early and prior to the graft placement procedure and the grafting should not take place before eight years old. Hovell recommended that serial grafting be performed routinely. Hovell made a pre-auricular incision and sectioned the ramus for the ankylosis below the lingula while preserving the neurovascular bundle. Hovell recommended

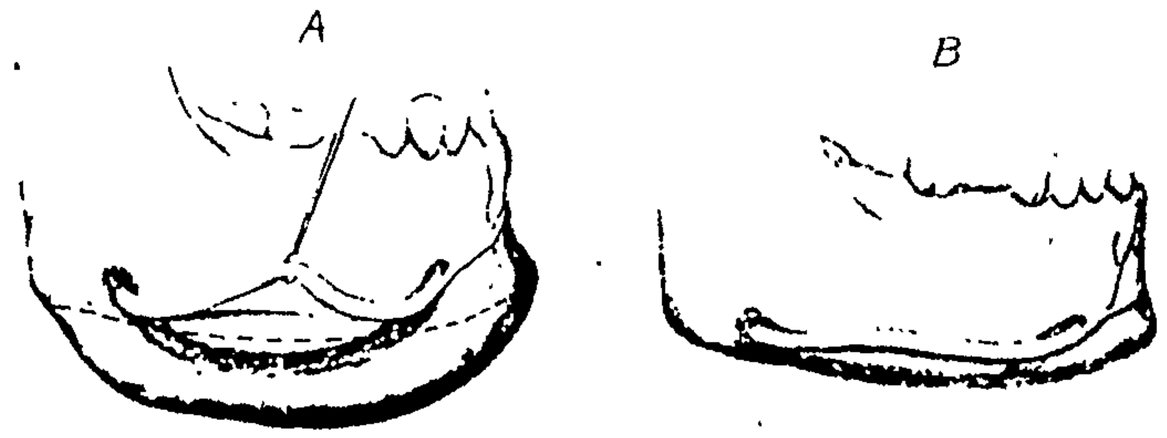
fixation for ten weeks.

In contrast to Hovell, Osborne recommended that the correction of the ankylosis be delayed as late as possible after grafting for the correction of the asymmetry. The grafting should be done before 6 years old, to allow as much compensatory growth of the maxilla as possible prior to the correction of the ankylosis. Hovell on the other hand recommended that the ankylosis be corrected as early as possible, and before there is any grafting for the correction of any asymmetry, which should not be done before the age of 8 years old. Osborne did not recommend serial grafting unless specifically indicated. Hovell did recommend serial grafting. Osborne's approach was a Risdon type approach with the ramus sectioned above the lingula in contrast to Hovell who makes a higher incision but sections the ramus below the lingula still however preserving the Mandibular neurovascular bundle. Furthermore Osborne recommended fixation only for five weeks, Hovell for 10 weeks.

Development of Unilateral Mandibular Overdevelopment Procedures.

Where the deformity of the mandible is clinically a unilateral protrusion or retrusion of the mandible, then those procedures developed for the correction of bilateral protrusion or retrusion would have been reported for the correction of asymmetry at some stage. For the most part, where the procedure would be suitable for the correction of bilateral protrusion or retrusion, then the procedure would be suitably adaptable for unilateral deformity.

The treatment of asymmetry has only recently been reported. Hence many of the reports mentioned are within the last forty years.



Transplantation of the inferior alveolar neurovascular bundle. Drawings illustrating, A) Line of resection of hypertrophied bone (shown by broken line). The neurovascular bundle has been lifted from the canal in order to preserve it. B) Appearance of mandible following resection of hypertrophied bone.

Converse & Shapiro's Lower Border Recontour "Shave" With Preservation of the Neurovascular Bundle. From Converse & Shapiro 1952.

Diagram 134

I. "Shave" Procedures.

The German literature mentioned the first time use of a lower border "shave" for the partial correction of asymmetry. Sercer and Bocak (Sercer & Bocak 1940) reported the use of a lower border recontouring or "shave" with the use of a horizontal ramus osteotomy for the correction of asymmetry. It was also the first time that both procedures had been used together for the correction of asymmetry. The use of multiple procedures for the correction of a single deformity of the mandible, at the one operation, was not commonly practised at that time. However more reports were to later appear in the literature.

Converse and Shapiro (Converse & Shapiro 1954) discussed, without citing cases, a similar procedure to Sercer and Bocak's but using an intra-oral approach, and not the extra-oral approach of Sercer and Bocak, and also with preservation of the neurovascular bundle. At that time, preservation of the bundle was becoming an important factor in the selection of procedures. See **diagram 134.**

Dingman and Grabb (Dingman and Grabb 1963) described a method for contouring the body of the mandible along the inferior and lateral borders for reducing bony overgrowth. This especially applied to cases of asymmetry. No cases were cited. The procedure was a refinement of both Converse and Shapiro, and Sercer and Bocak. The approach suggested was an extra-oral one.

Walker (Walker 1967) performed a procedure similar to Sercer and Bocak, and which was an advance on McNichol and Roger's multi-stage procedure that is mentioned further on (McNichol & Roger 1946). In a case of gross unilateral condylar hyperplasia, Walker resected the inferior border as a "shave" procedure with preservation of the neurovascular bundle, and performed a bilateral body osteotomy to reset the mandible and to correct the chin deviation at the same time.

Erickson and Waite (Erickson & Waite 1974) documented a case of an inferior border "shave" that was similar to the one described by Dingman and Grabb but with the addition of an onlay bone graft to the lateral aspect of the ramus on the same side at the same operation.

The first noted case report of an inferior border "shave" by an oral approach, as distinct from suggestions previously noted without case reports, was by Mavaddat (Mavaddat 1971), followed by Hinds and Kent (Hinds & Kent 1972), Blair and Schneider (Blair & Schneider 1977) and then Schmid (Schmid 1978) who also reviewed procedures in general for the correction of asymmetric facial deformities. Mavaddat also performed a unilateral ramus sagittal split procedure to further correct the asymmetry, as a second stage

procedure approximately six weeks later.

II. Body Osteotomies Procedures.

The use of multi-stage procedures was demonstrated by McNichol and Roger (McNichol & Roger 1946) who reported a five stage operation for the correction of gross asymmetry and mandibular hyperplasia due principally to condylar hyperplasia. The first stage was a bilateral ostectomy of the body of the mandible, which was a "shave" procedure similar to that performed by Sercer and Bocak (Sercer & Bocak 1940). The second stage was the addition of bone (iliac crest) grafts to the ostectomy sites. The third stage was a genioplasty of the asymmetric chin prominence to place the prominence more symmetrically. The fourth stage was the insertion of dermal fat grafts to the concave side of the face to alter the contour and reshape the face. The fifth stage was a repeat of the fourth stage where the grafting was insufficient. Splinting was with the use of preplanned cast splints, which were placed prior to the first operation.

The above multi-stage operation had the advantage of achieving a better occlusion than many of its predecessors for the correction of asymmetry, and a better facial contour as well. But there was the disadvantage of sectioning of the Mandibular nerve with subsequent loss of function distal to the section and graft. Overall, the authors considered this to be secondary to sectioning at the condylar neck or resection of the condyle.

Jacobs, Rafel and Weiss (Jacobs, Rafel & Weiss 1953) suggested the use of a unilateral body procedure, but this time on the hyperplastic side and not the hypoplastic side as suggested by Limberg. The procedure was also for the correction of body

hyperplasia but the aim of the procedure was to shorten the long side by a vertical body section, removing a parallelogram of bone, and wiring the fragments together after closing the gap.

Fickling and Fordyce, in a review of the methods of correcting prognathism and retrognathism, suggested that a bilateral body procedure be best used for the correction of body asymmetry. On the deficient side an osteotomy be used with any necessary expansion gap filled with bone chips from the iliac crest. On the hyperplastic side, an osteotomy with the removal of a parallelogram of bone to shorten that side (Fickling & Fordyce 1955). This approach has been endorsed by Sandor et al (Sandor, Stoelinga & Tideman 1982) in an extensive review of the step body osteotomy.

Plumpton (Plumpton 1967) recommended the use of a unilateral body ostectomy. The procedure was a vertical section of the body anterior to the mental foramen, with removal a block of bone sufficient to reduce the asymmetry. The approach was an intra-oral approach using partial degloving of the mandible sufficient for access only. The procedure was indicated where there was a normal maxilla, a contralateral cross bite, and an ipsilateral open bite, reverse crossbite or normal occlusion.

III. Muscle Resection.

Where the deformity is related to excessive gonial angle hypertrophy, either muscular or bony then an appropriate muscle excision and/or ostectomy is required. The approach can be either an extra-oral one using a Risdon type approach, or an oral one using an adapted third molar type of incision with further extension of the flap design to allow greater instrumentation and access to the gonial angle. The masseter is stripped from its attachment at the gonial

angle, and the appropriate amount of bone removed. Masseter is not sutured but allowed to reattach itself. Where hypertrophy of the masseter is a factor in the deformity then it is partly trimmed to reduce its bulk, prior to closure. (Longacre, DeStefano & Holmstrand 1961.)

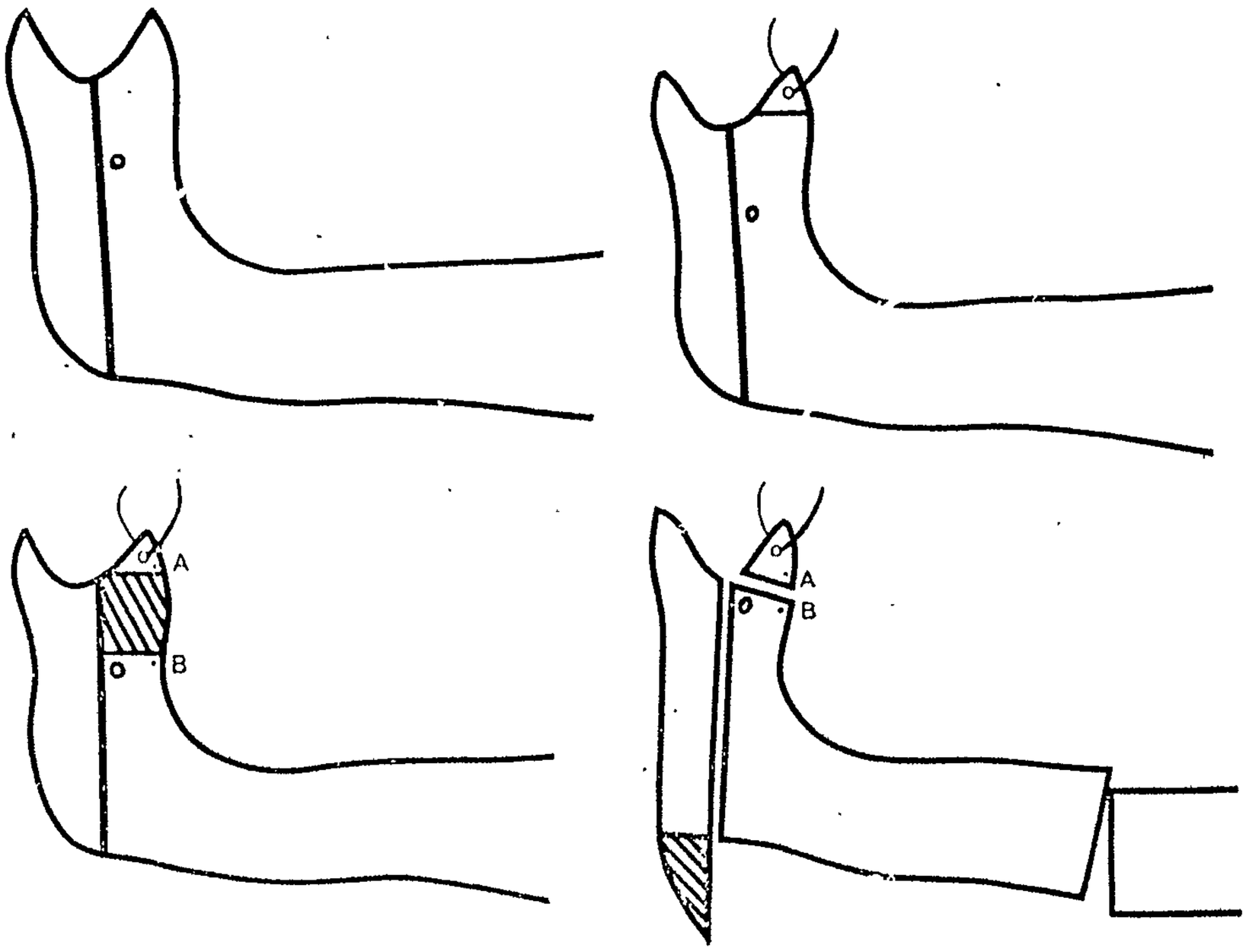
IV. Ramus Procedures.

Gottlieb (Gottlieb 1951) wrote the first major review of procedures for the correction of asymmetry which included a review of all the cases previously reported in the literature from the known sources at the time. While Gottlieb did miss a few reported cases, it was an excellent review. Gottlieb noted that the vast majority of surgical treatments for the correction of asymmetry were condyle procedures, of which the most common was condylectomy. Gottlieb noted that condyle procedures were not always the treatment of choice. On occasions, other modes of surgical treatment were better indicated. Gottlieb used a bilateral horizontal osteotomy of the ramus with a few of the twelve cases that he reported having corrected.

Gottlieb used two approaches. For his condylectomy procedure he used a "Bochenheimer - Axhausen" approach using Local and Regional anaesthesia. This approach divides the external auditory meatus to gain access to the neck of the condyle from the posterior approach. He then used a hammer and chisel to resect the condyle head. The stump was then smoothed and the disk removed. Intermaxillary fixation was for three months followed by occlusal equilibration. For his horizontal ramus procedure, Gottlieb used a vertical incision commencing from just below the lobe of the ear. The section was performed by a Ragnell saw.

Hinds, Reid and Burch (Hinds, Reid & Burch 1960) in a review of mandibular asymmetries, noted that condylar hyperplasia as a cause of asymmetry is not rare. They noted that the condyle itself was not always abnormal. In such cases, and when the hyperplasia had ceased, then surgery through the ramus was indicated. They reported a case corrected by unilateral vertical oblique sliding osteotomy. A procedure that allowed the condyle to stay in its anatomical position while the remainder of mandible was resited into a (new) more balanced position aesthetically. Subsequently Hinds (Hinds & Kent 1972) recommended that a bilateral subcondylar procedure be performed at the same time to correct the asymmetry. This procedure was recommended as being particularly suited to adult hyperplasia.

A variation of the vertical oblique sliding osteotomy of the ramus was used by Fox (Fox 1977) in a multi-stage operation for the correction of open bite due to gross asymmetry. See **diagram 135.** The ramus was sectioned in the normal manner of a vertical oblique sliding osteotomy and the body of the mandible sectioned vertically at the symphysis. A parallelogram of bone was taken from the anterior segment of the ramus above the lingula and below the coronoid process. The anterior fragment, which included the body of the mandible, was then raised to meet the coronoid process by the amount of bone that was removed as a parallelogram. The raised anterior fragment of bone was wired to the coronoid process. The raised anterior fragment was also wired to the posterior fragment at the same time. The posterior fragment was not raised. The angle of the mandible, attached to the posterior fragment, now protruded below the level of the new, raised, lower border. This angle was removed to create a new angle that was flush



(top left). Vertical subsigmoid osteotomy.

(top right). Loop of wire inserted through tip of coronoid process and coronoid process with temporalis muscle attached, cut from the ramus.

(bottom left). Superior part of the ramus anterior to the vertical subsigmoid cut resected down to the level of the mandibular foramen.

(bottom right). Body of mandible sectioned in midline and moved upwards 2 mm at midline. Ramus and body then rotated upwards about the upper point of the symphyseal section so that the new anterior superior aspect of the ramus, point B in the diagram, is moved up to point A. The tip of the coronoid with the attached temporalis is wired to the new anterior superior aspect of the ramus. The excess length of the inferior aspect of the posterior section of the mandible is then excised.

Fox's Multi-sectioned Ramus Osteotomy for the Correction of Mandibular Asymmetry.
From Fox 1977.

Diagram 135

with the new lower border. The sectioned removed pieces of bone (the old angle of the mandible and the parallelogram of bone from below the coronoid process) were chipped and used to fill in the bony gaps at the symphysis after the symphysis was wired to its new position.

Previously Georgiade and Quinn (Georgiade & Quinn 1961) performed a similar procedure for the correction of open bite caused by mandibular hypertrophy and asymmetry. However these two surgeons adapted Caldwell and Letterman's decortication technique of

the fragments prior to removing the angle of the mandible and the parallelogram of bone from beneath the coronoid process. The procedure was very successful. Like the above procedure reported by Fox (Fox 1977) there has been a tendency to perform procedures that are more complicated and have many sections, and to perform them all at the same time instead of on different occasions such as the multi-stage procedures performed by McNichol & Roger (McNichol & Roger 1946). This does have several advantages. The patients are not put through the trauma of surgery more than once. The morbidity of the total operation is decreased. The result is more readily apparent for both patient and surgeon. Severe deformities can be corrected to a greater degree. On the other hand the disadvantages are that the single operation carries a greater risk of morbidity. The procedure is longer in time of operation. Very careful planning of the surgery is required as assessment at the time of surgery is not possible. Nor can the results be reassesed and compensated for subsequently if the previous procedure(s) is unsatisfactory.

Ramus procedures for the correction of asymmetry are also preferred by Bell et al (Bell, Proffit & White 1980) in combination with genioplasty procedures, usually of the horizontal body osteotomy type. The use of ramus procedures, with or without genioplasty procedures would appear to be the currently preferred method of treating mandibular asymmetry when not amenable to condyle surgery alone.

Summary.

Multiple procedures have become more common in the treatment of asymmetry than in the treatment of other forms of mandibular malrelationships. This is because with asymmetry, the

deformity is not always located in a single area, but in several areas.

In general the following procedures are recommended for the correction of asymmetry by Epker & Wolford. (Epker & Wolford 1980).

1. Contralateral ramus osteotomy.
2. Ipsilateral ramus osteotomy.
3. Ipsilateral reduction of the inferior border of the body of the mandible.
4. Straightening genioplasty.
5. Maxillary levelling procedures.

The use of ramus and body procedures for the correction of asymmetry is indicated where the problem has affected the occlusion and where the problem is in more than one area and requires compensatory surgery on the "unaffected" side. This is particularly so where the occlusion has been disrupted, and a single procedure is unlikely to correct the problem.

Frequently with adult asymmetry caused by condylar hyperplasia there is a lateral open bite produced on the affected side with a crossbite developed on the unaffected side. In such cases a combination of condylectomy to treat the condylar hyperplasia and a ramus or body procedure or procedures to correct the lateral open bite on the (same) affected side and the crossbite on the (contralateral) unaffected side are used. Treatment of the condyle hyperplasia alone such as with a condylectomy may restore the occlusion but still leaves a base bone deformity where the condition has not been treated sufficiently early.

Where the asymmetry presents with a satisfactory occlusion, but also a mandibular base bone deformity there is usually accompanying compensatory maxillary growth. The result is a functioning occlusion with an asymmetry of the lower third of the face, a combination of both mandibular and maxillary deformity. In such cases both mandibular and maxillary surgery is required to correct the problem.

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MANDIBULAR ASYMMETRY

Genioplasty Procedures

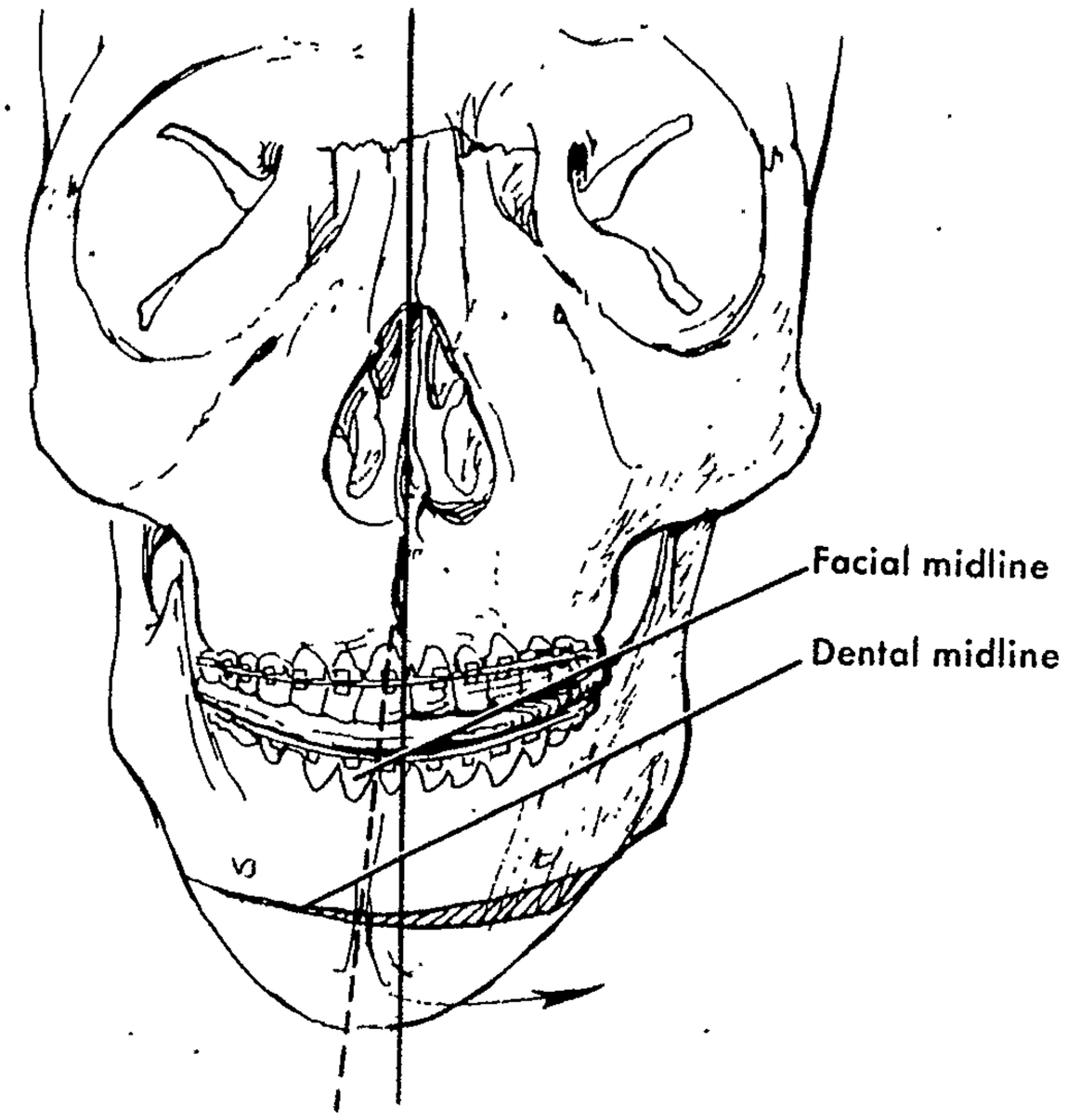
Introduction.

Where asymmetry is not correctable, partially or totally, by repositioning of the ramus/body and the occlusion, then genioplasty is indicated. Problems that will often require symphyseal surgery in conjunction with other surgical procedures, or by itself range from hemifacial microsomia, to laterognathism, condylar hyperplasia and Temporomandibular joint ankylosis, to simple chin asymmetry. These deformities can be regarded as being possible indications for the use of straightening genioplasty procedure(s).

Discussion.

Plumpton (Plumpton 1967) was one of the first to report a symphysis procedure only for the correction of asymmetry. The procedure required the simple vertical section at the symphysis (an ostectomy) and the removal of a parallelogram of bone. The asymmetric mandible was realigned according to predetermined cast locking splints and the fragments fixed accordingly. The procedure allowed the correction of an unstable occlusal table and the correction of a unilateral cross-bite. Plumpton recorded good success. Indications for the procedure would be limited to mandibular deformities where the degree of compensatory maxillary asymmetry would be minimal or not at all.

Epker and Wolford (Epker & Wolford 1980) recommended that where ramus or other non-symphyseal body procedures were not amenable to the correction of anterior body asymmetry, i.e.

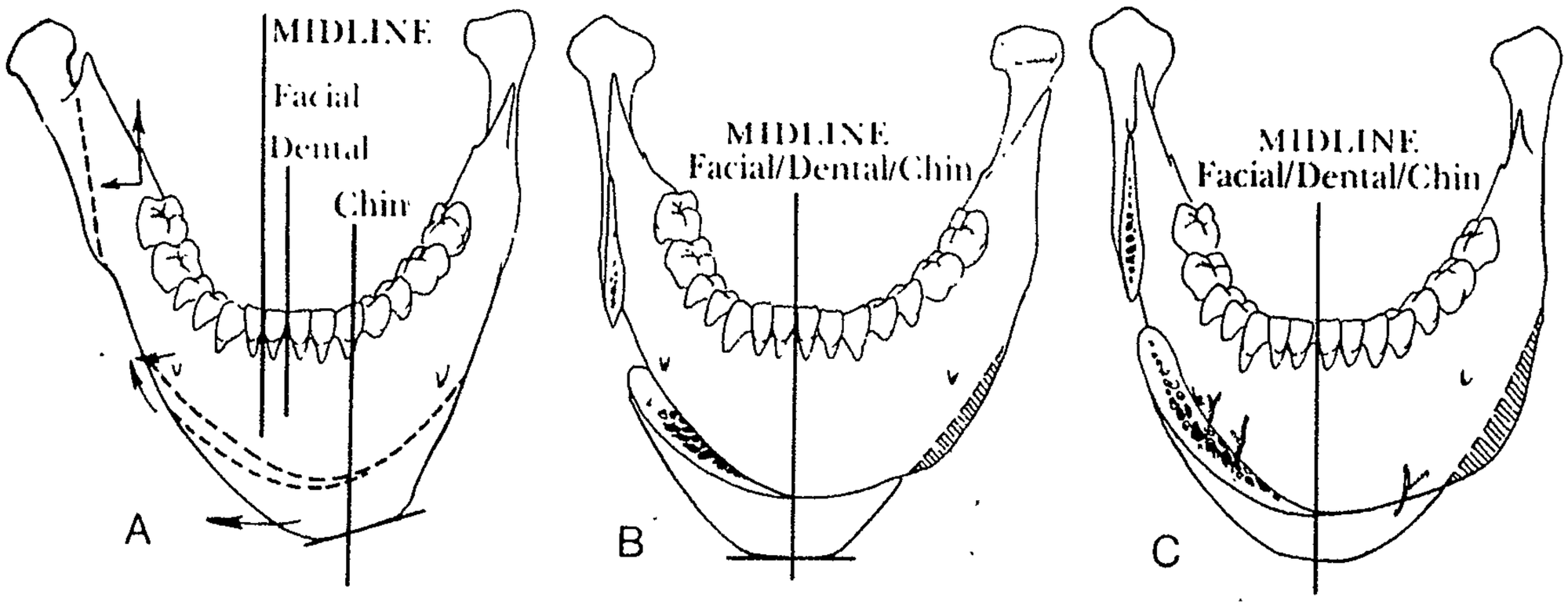


Epker & Wolford's Symphysis Straightening Procedure. From Epker & Wolford 1980.

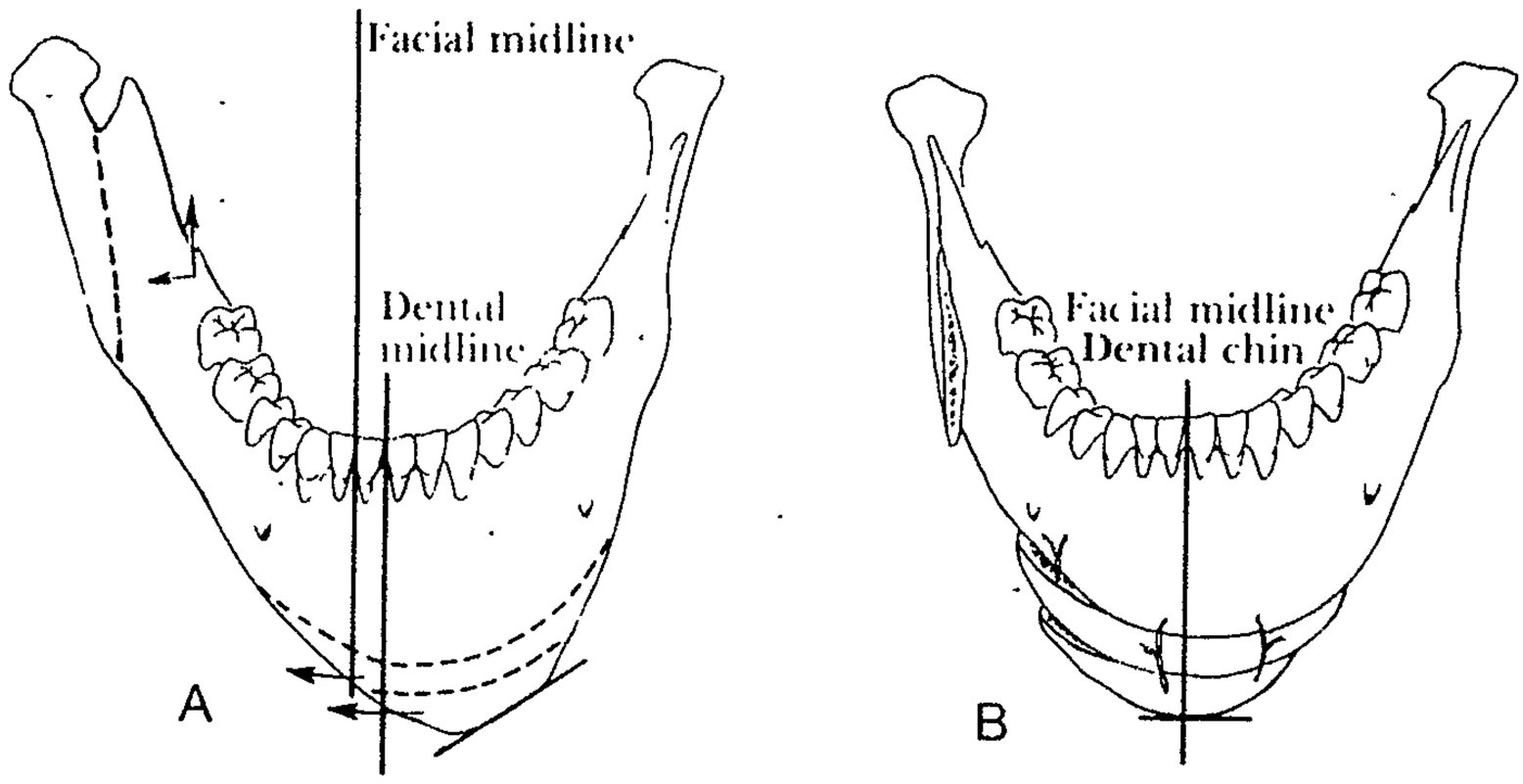
Diagram 136

symphyseal asymmetry, then the procedure of choice was the horizontal body osteotomy. As an important part of the horizontal osteotomy procedure where used for the correction of asymmetry, Epker and Wolford emphasised the need to firstly score the required midline prior to sectioning, and secondly not to completely deglove the mandible, but to deglove only sufficiently to allow access for the surgery. Usually one side (the larger side) required an ostectomy, and occasionally the smaller side required graft boosting. See **diagram 136.**

With many asymmetry problems, correction to the vertical dimension and the antero-posterior dimension was required. This was a further advantage and reason for using the horizontal osteotomy. Careful planning of the final position of the fragment



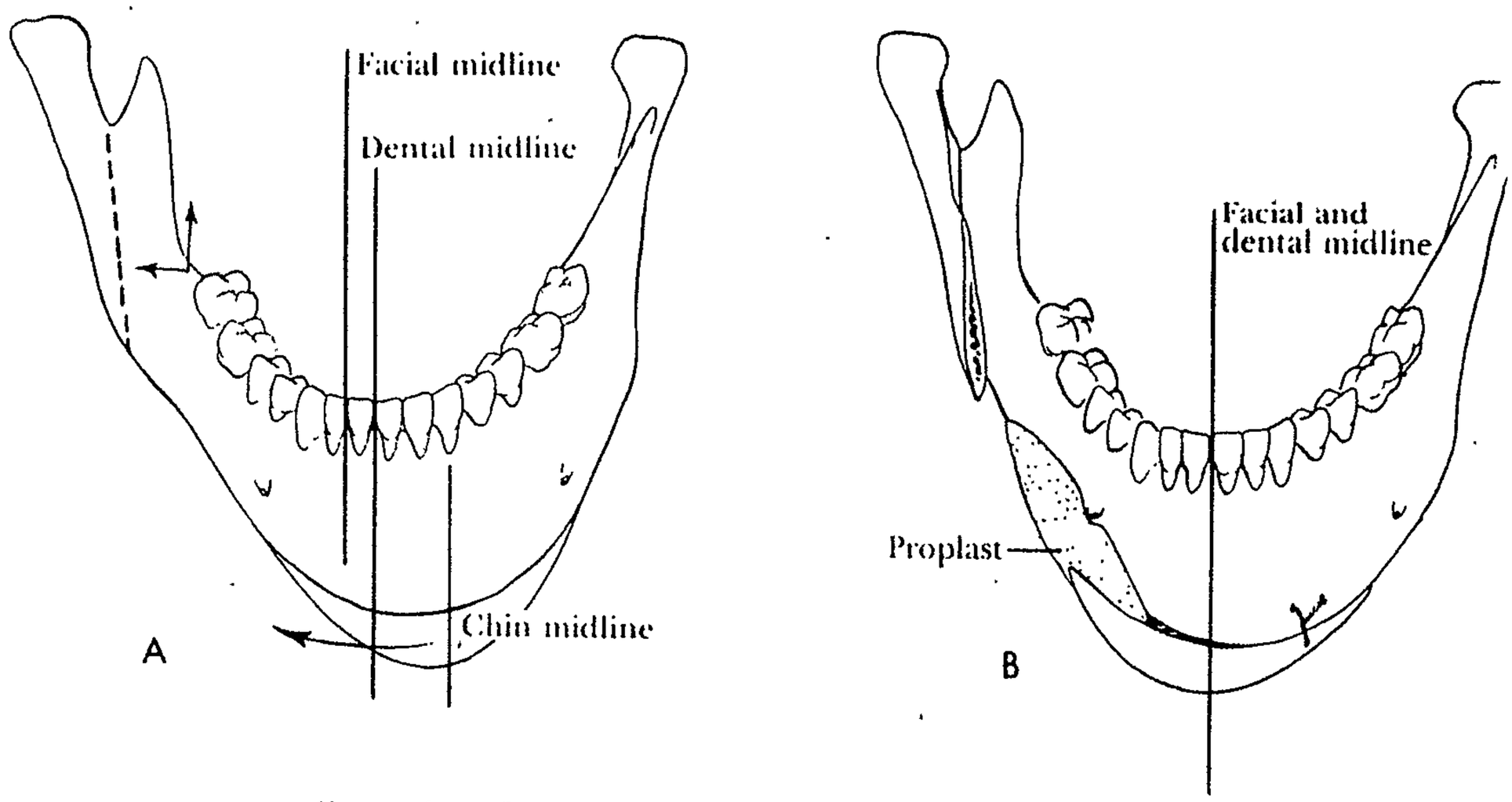
Oblique sliding wedge ostectomy. *A*, Oblique sliding wedge ostectomy to correct chin asymmetry; vertical ramus osteotomy for establishing dental and ramus symmetry and leveling occlusal plane. Arrows indicate directional movement of ramus and chin segments; area between dotted lines is proposed wedge ostectomy. *B*, Mandible shifted by ramus osteotomy to establish dental and ramus symmetry. Chin leveled by wedge ostectomy and midline corrected by lateral shift of segment; chin segment maintained under mandibular segment. Hatch marks indicate area of possible lateral ostectomy to achieve final contour. *C*, Mandible shifted by ramus osteotomy; chin leveled, maximal lateral augmentation achieved by stabilizing chin segment lateral to labial cortex of superior segment. Possible ostectomy indicated by hatch marks.



Double lateral sliding osteotomy. *A*, Double lateral sliding osteotomy for correction of asymmetry. Vertical ramus osteotomy helps to level the occlusal plane, coordinates the dental and facial midlines, and establishes ramus symmetry. Arrows indicate directional movement of ramus and chin segments. *B*, Mandible shifted by ramus osteotomy to establish dental and ramus symmetry; chin segments repositioned laterally and stabilized to establish chin symmetry.

From Bell, Proffitt & White 1980.

Diagram 137



Correction of mandibular asymmetry by ramus osteotomy, transverse sliding osteotomy, and lateral augmentation with Proplast. *A*, Mandibular asymmetry with discrepancy between dental, chin, and facial midlines. *B*, Ramus osteotomy corrects the dental and facial midline discrepancy and partially corrects the chin asymmetry; transverse sliding osteotomy establishes facial and chin symmetry; midbody contour deficiency is augmented by Proplast implant

From Bell, Proffitt & White 1980.

Diagram 138

made it possible to correct other discrepancies simultaneously. (Epker & Wolford 1980).

Bell et al (Bell, Proffit & White 1980) described the use of a horizontal body osteotomy for the correction of chin asymmetry, with the use of Proplast to fill any remaining deficient contour on the unaffected side. This procedure is recommended where the occlusion is normal or at least satisfactory and the vertical dimension does not require correction. Where there is an occlusal discrepancy (open bite on the affected side and crossbite on the unaffected side) then a vertical subsigmoid procedure was recommended to correct the occlusal discrepancy. If the symphysis asymmetry was severe, then a double layer horizontal body osteotomy lateral shift was recommended. See **diagram 137.** According to Bell et al, the horizontal body osteotomy was the procedure of choice for correcting

most chin asymmetries.

Where there is a vertical dimension problem as well as a symphysis deformity, then Bell et al recommended the use of a wedge ostectomy of the symphysis combined with a horizontal body osteotomy. By removing the appropriate amount of bone as a wedge, the vertical dimension of the chin can be altered at the same time as the chin's asymmetry is corrected. In all cases Bell et al recommended that a shave procedure of the affected side, and if necessary, Proplast filling of the deficient side be considered, if the contour of the mandible after a horizontal body osteotomy is unsatisfactory. (Bell, Proffit & White 1980). See **diagram 138.**

Summary.

Genioplasty procedures have a limited but necessary place in the treatment of asymmetry. Example would be where either the generalised asymmetry is minor and there is no wish to change an asymmetric but acceptable occlusion but only the appearance of the patient. Or in those cases where the the symphysis is independently asymmetric with or without other asymmetric features and therefore requires treatment of itself.

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MANDIBULAR SYMPHYSIS DEFORMITIES

Introduction.

Deformities of the chin will be limited in this chapter to macrogenia and microgenia problems. Some deformities of the chin will overlap in nature and treatment with other deformities. This applies in particular to lateral deformities which appear as asymmetry problems not necessarily limited to the chin. These deformities not limited to the chin will be treated as though they are part of the main problem. I.e. lateral or asymmetric chin deformities will be discussed in body and asymmetry chapters respectively.

Areas discussed will be:

A. Microgenia (Enlargening procedures).

B. Macrogenia (Reducing procedures).

Most of the research and development in the area of genioplasty has been on the correction of microgenia. The main development in this area was the introduction of the Horizontal Body Osteotomy of the mandible by Obwegeser and Trauner in 1957. There have been many variations since that original procedure that have been adapted for the treatment of various symphyseal deformities. The original enlargening procedures were of the autogenous augmentation type, being the simplest and most effective way to produce a change in shape. The same applies to the reverse procedures of reducing the symphysis. The original procedures were simply "shave" procedures that reduced the contour of the bone but often did not achieve the desired soft tissue contour. It was for this reason that the horizontal osteotomies with partial periosteal stripping of the symphysis have been developed.

The horizontal osteotomy of the body has proved to be very versatile in correcting many types of chin deformities, including asymmetry.

The problems of substituting for bone are discussed. The desired aim of eliminating the need for a second procedure to procure bone for grafting has not yet been achieved, although Proplast appears to be a promising substitute. There have been many materials examined in the past and so far none have been shown to be completely satisfactory.

Discussion.

The first area of deformity that will be discussed will be microgenia. Symphyses that are deficient either vertically, antero-posteriorly or both will be considered. The procedures discussed are designed to enlarge the symphysis.

The second area of deformity that will be discussed is macrogenia. Enlarged symphyses that require reduction procedures either vertically, antero-posteriorly, or both will be considered.

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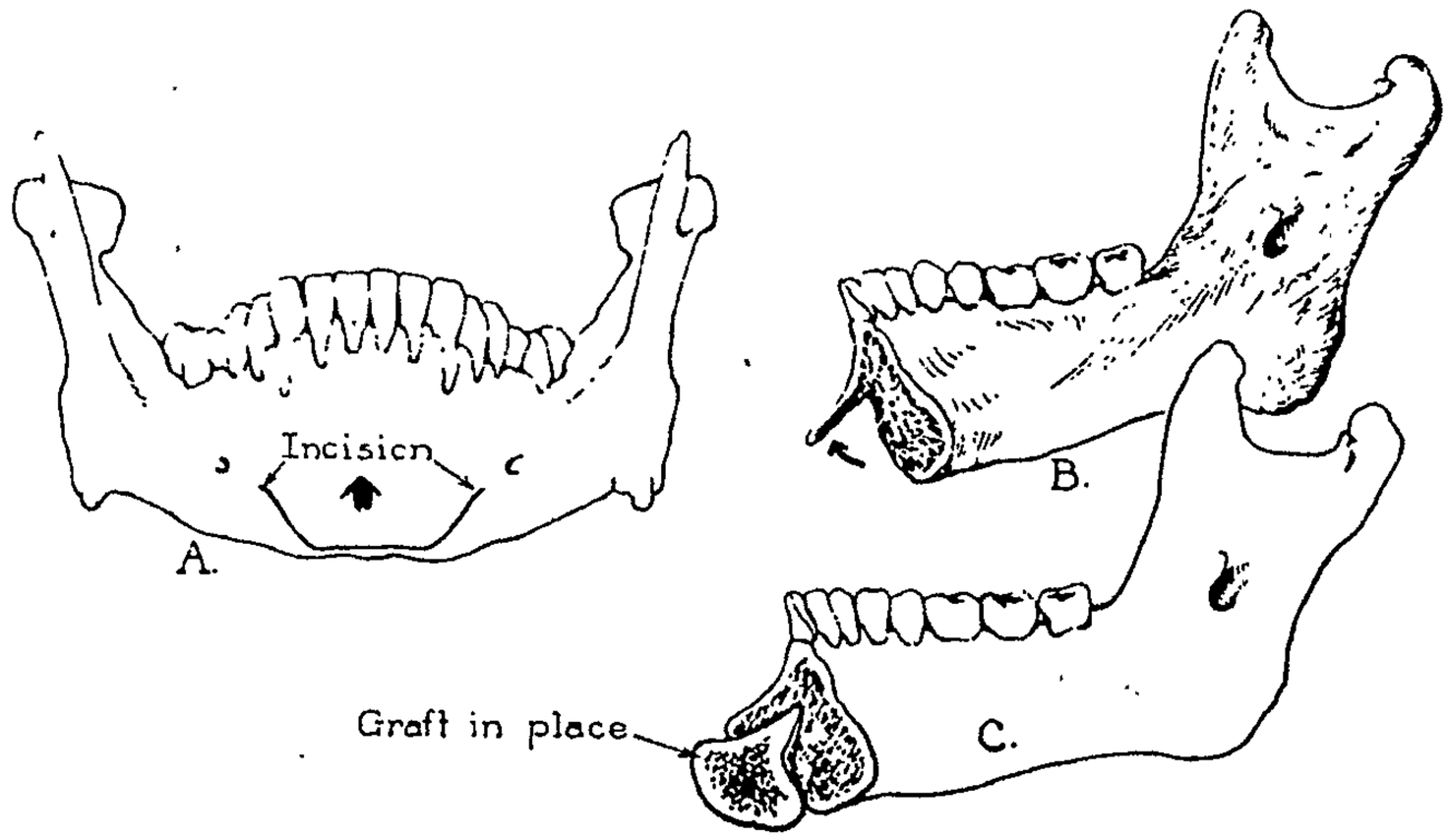
MANDIBULAR SYMPHYSIS DEFORMITIES

Microgenia Procedures

Development of Autogenous Augmentation Genioplasties.

Hensel (Hensel 1937) reported on a problem relating to the correction of microgenia when present with micrognathia /retrognathia and insufficient advancement was obtained. In such circumstances, Hensel recommended that a genioplasty be performed to correct the remaining discrepancy, as a supplementary procedure subsequent to body or ramus advancement procedures.

Hensel's approach was extra-oral via a curved incision under the chin. The cutaneous and subcutaneous tissue were retracted, but the periosteum was not stripped. A curved bony section was made into the bone for a depth of approximately half an inch. The curve of the section went both upwards and backwards with a base towards the crowns of the teeth. Using the periosteum as a hinge, the bone was elevated up to expose a wedge of bone between the raised anterior surface of the symphysis and the cancellous bone of the remainder of the mandible. An iliac crest graft was taken and shaped like a wedge to be placed into the gap between the two surfaces of the symphysis. Hensel recommended that no fixation be used, but should the graft wedge feel loose, then Hensel recommended that two beef bone pegs could be driven through the anterior cortical bone, through the iliac graft to pin the two layers to the main body of the mandible. The question of antigen reaction must be considered. It is highly unlikely that the routine use of beef pegs to stabilise the fragments would be of benefit.



Semidiagrammatic representation of mandibular graft operation. *A*, Incision; *B*, elevated outer table; *C*, graft implantation.

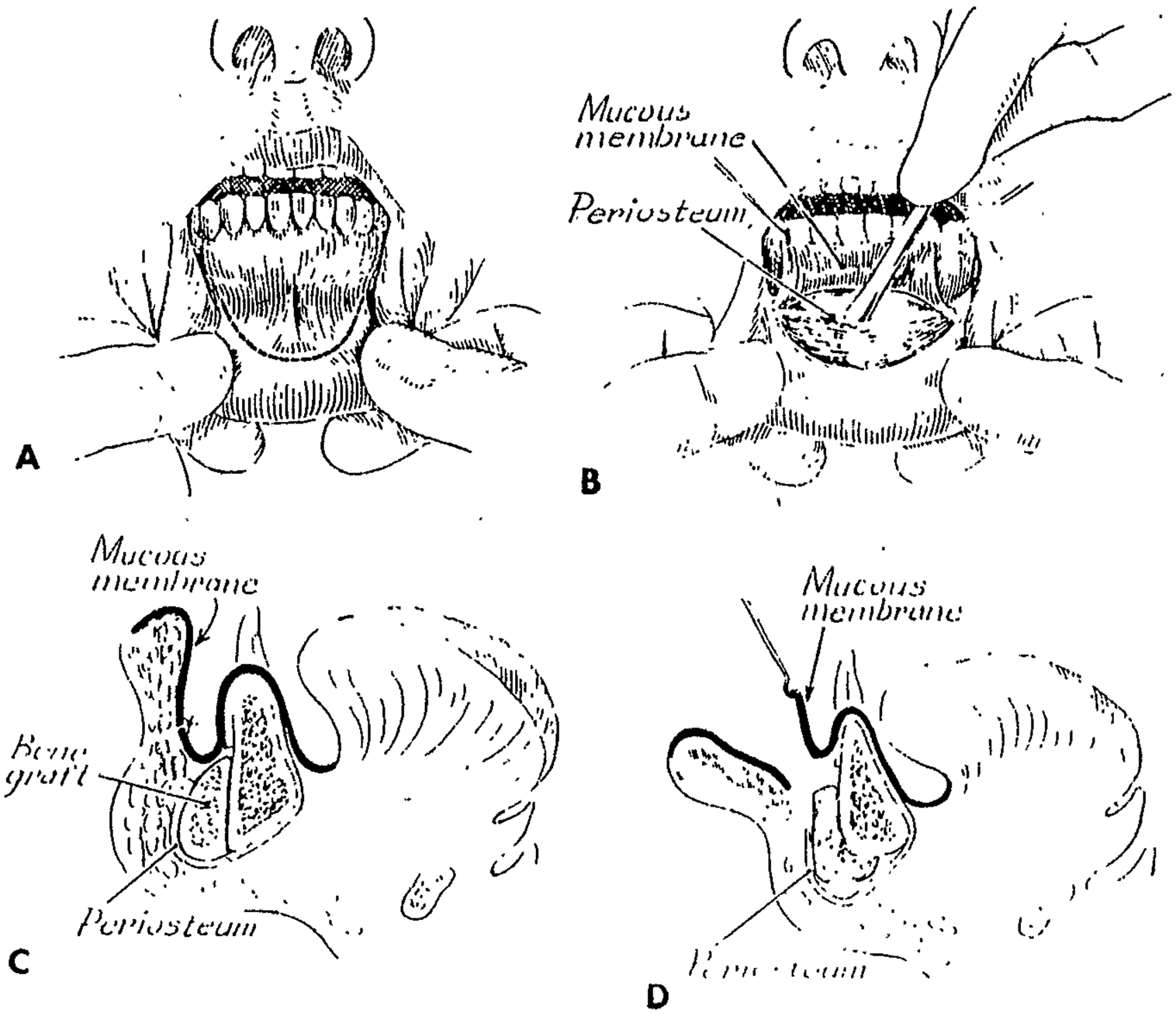
Hensel's Genioplasty Osteotomy.
From Hensel 1936.

Diagram 139

By varying the size of the graft that was wedged between the two layers of the symphysis, various degrees of retrusion and chin obliquity could be corrected. Hensel recommended the technique as both sides of the graft received nutrition from normal, uninterrupted sources. See **diagram 139.** Hensel followed up his cases for three years and found no resorption of the grafts.

Babcock (Babcock 1937) suggested that a cartilage or fat graft be added onto the symphysis as a boost to the contour of the symphysis in similar circumstances to those described by Hensel i.e. inadequate advancement of the symphysis despite sufficient mandibular body advancement. However he showed no cases to further the suggestion.

Up to the late 1940's autogenous bone and cartilage grafts were the only acceptable means of producing augmentation of



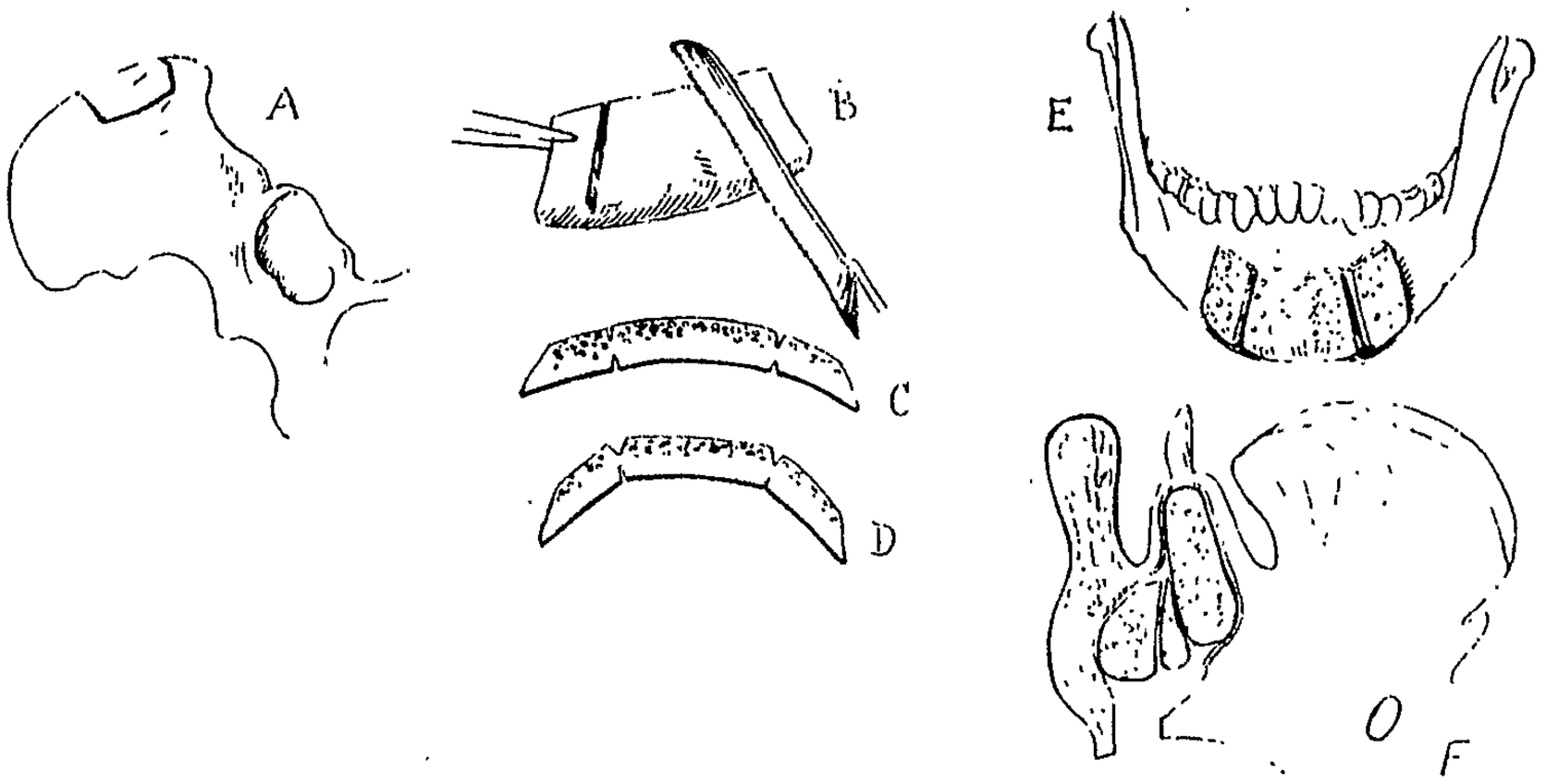
Bone grafting by the intraoral approach. *A*, The line of incision in the mentolabial sulcus. *B*, The mucous membrane flap is raised; the periosteum is then incised and elevated from the mandible. *C*, The bone graft in position. Note the apposition of the cortical bone of the graft to the cortex of the mandible. *D*, An L shaped bone graft in position to increase the vertical dimension of the mandible. *E*, The optimal site of removal of the bone graft from the inner table and crest of the ilium. *F*, Immobilization of the bone graft and obliteration of dead space by an Elastoplast dressing

Converse & Wood-Smith's Labial Approach for Symphysis Grafting.
From Converse & Wood-Smith 1964.

Diagram 140

the chin. This of course had the major disadvantage of requiring a donor site and a more minor one of requiring time to shape prior to insertion but is still a popular operation for the correction of chin deficiencies.

Converse and Wood-Smith (Converse & Wood-Smith 1964) suggested for the treatment of microgenia, an intra-oral procedure placing the graft so as to allow sufficient tissue flexibility to accommodate the graft and avoid wound breakdown. The



Bone grafting through the extraoral approach. *A*, The optimal site of removal of the bone graft. *B*, Division of the bony cortex. *C*, Cortical and cancellous portions of the bone partially divided. *D*, Greenstick fracture of the bone graft done so that its contour will conform to that of the mandible. *E*, The bone graft applied to the anterior aspect of the mandible. *F*, Additional wedges of bone added under the main bone graft.

Converse & Wood-Smith's Placing and Shaping of Iliac Crest Grafts, Using a Submental Approach.
From Converse & Wood-Smith 1964.

Diagram 141

incision is made on the alveolar aspect of the lower lip above the origin of the frenulum. The incision is made to the depth of the mucosa only and the orbicularis oris is dissected from the mucosal lining until the periosteum is exposed. The periosteum is then incised and raised, and the symphysis is exposed. See **diagram 140.** The routine use of the oral approach was made possible by the introduction of antibiotics to control infection, a common problem before the use of antibiotics with oral approaches.

Converse & Wood-Smith explained the method of obtaining and placing grafts, using the submental approach. See **diagram 141.** Grafts should be placed with the cortical layer against the symphysis and the cancellous layer facing the skin for the

following reasons:

1. The cancellous surface is carved and shaped more readily.

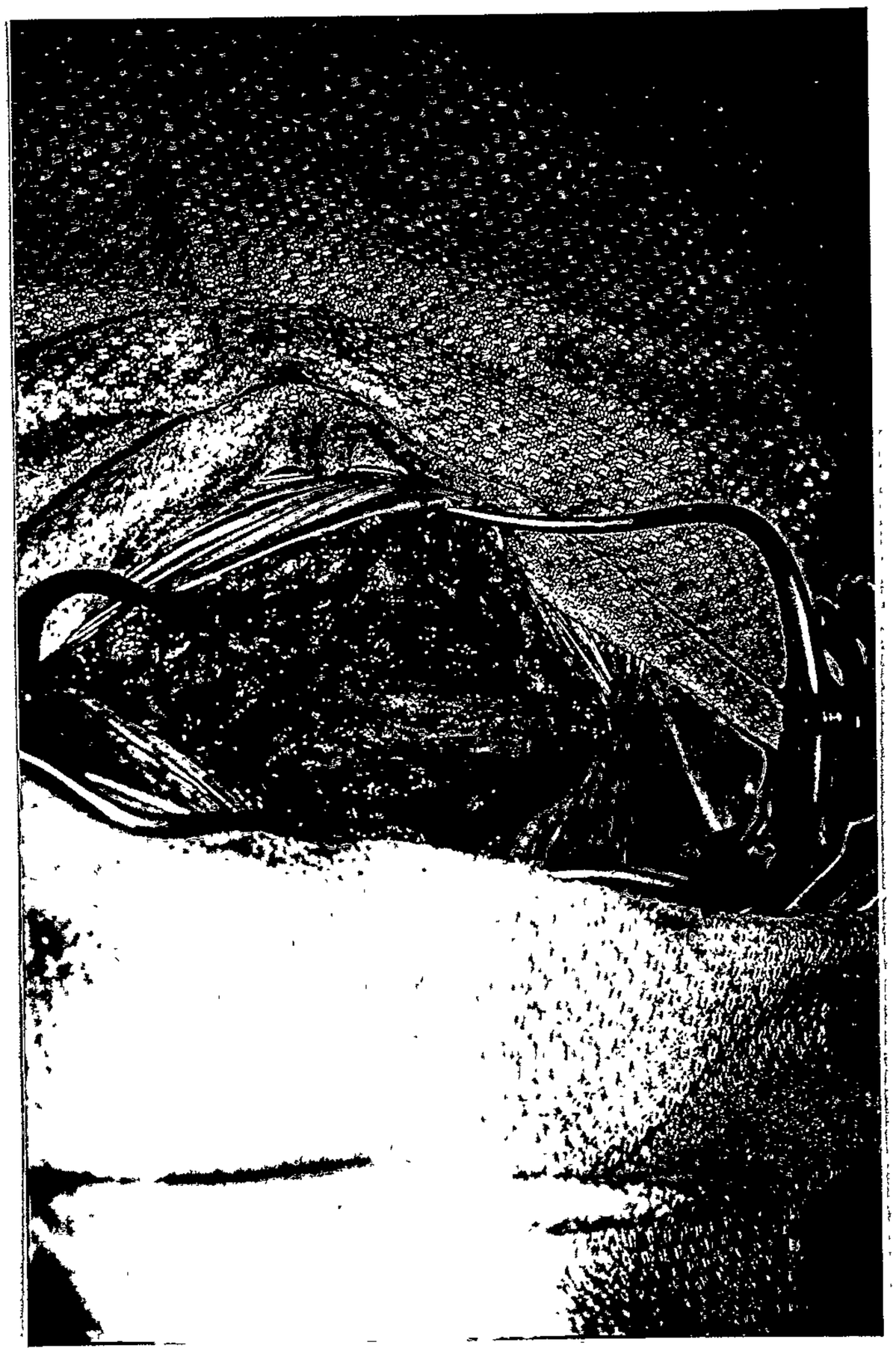
2. The graft bends more easily, to adapt to the symphysis, if cuts are made in the cortical layer and the graft bent backwards opening out the cancellous layer.

3. There is more rapid revascularisation of the graft if the cancellous layer faces the skin.

Where the graft is properly shaped then the contour of the symphysis can not only be boosted anteriorly, but by the use of a hooked graft that fits under the symphysis, the symphysis can be boosted inferiorly as well as anteriorly. See **diagram 141.** The site for the graft on the Iliac Crest is demonstrated in **Illustration 9.**

The use of a direct extra-oral approach for the correction of microgenia would be best suited to those cases that require the removal of submental fat to produce a better contour post-operatively. The extra-oral approach is also recommended where synthetic graft materials are used.

Other materials used for grafting, as well as autogenous bone, have been cartilage or bone (homogenous) bank material. (Trauner & Obwegeser 1957). Smith and Johnson (Smith & Johnson 1940) recommended the use of rib cartilage for the correction of microgenia. The rib was placed via an extra-oral three centimetre curved incision beneath the symphysis. The rib was shaped to fit the mandible and fixed in place with plain catgut sutures.



Iliac Crest Site for Autogenous Bone Grafts

Illustration 9

Development of Alloplastic Augmentation Genioplasties.

The use of synthetic onlay grafts was first reviewed by Scales (Scales 1953) who outlined the problems associated with these materials. This was supported by Brown et al (Brown, Ohlwiler & Fryer 1960). The latter authors preferred the extra-oral approach. This they claimed allowed them to stabilise the onlay more readily. Brown et al listed three disadvantages of the synthetic onlay. These were:

1. Slippage, most of which occured vertically, and was the main disadvantage.
2. The second disadvantage was that of infection from compounding the graft. Often the result of vertical slipping that became compounded into the mouth.
3. The third disadvantage was that of bony resorption from pressure necrosis caused by the graft.

A fourth disadvantage would be the mobility of the graft, which could give rise to worse looking deformities than the original problem.

The materials that Brown, Ohlwiler and Fryer examined were silicones and halogenated carbons. They listed the following advantages to the use of these materials.

1. They were easy to obtain and store and therefore did not require special holding banks.
2. They were easy to shape.
3. There was no detectable antigen activity and little tissue activity against the materials.
4. They were stable materials, neither calcifying nor degenerating.
6. They were inexpensive.
7. They were readily and repeatedly sterilisable.

Trauner recommended the use of acrylic, placed by an extra-oral approach, which had been shaped by a wax pattern. He reported good results. (Trauner 1954; 1955). Thoma (Thoma 1948) recommended the use of Tantalum gauze material. Gonzalez-Ulloa and Stevens used as a guide the cephalometric Frankfort and Nasion lines. Taking 90° as the standard line, for mild cases (less than ten millimetres) then silastic was the material of choice. For moderate cases (between ten and twenty millimetres from base line) they recommended that acrylic be used, placed via an intra-oral approach. For severe cases (greater than twenty millimetres), then a retrocondylar implantation should be used (after Trauner and Obwegeser 1957) in addition to the use of acrylic at the symphysis as for moderate cases.

The most common synthetic graft material used today is silicone either as a solid implant (Bell 1969a), or as a sponge (Brown, Ohlwiler & Fryer 1960), followed by acrylic (Trauner 1954; 1955), and then perhaps Proplast (Kent, Westfall & Carlton 1981). The results would indicate minimum complications. All such grafts require good securing as unlike bone, the synthetic onlays can never become part of the bone the way a bone graft will. Hence the external approach should be used to help prevent vertical migration, and decrease infection associated with the intra-oral approach.

Meyer et al. (Meyer, Gehrig, Funk & Beder 1967) were amongst the first to report on the use of silicone rubber for bolstering facial contour, the chin in particular. The report was early and did not examine the use of the material in the long term. They noted that the material appeared to be compatible with the soft tissues, was adaptable in shape and simple to insert.