Gonzalez-Ulloa and Stevens (Gonzalez-Ulloa 1968) recommended that in cases of mild chin deficiency (less than 10 millimetres from a 90^0 Frankfort-Nasion line) silicone injected supra-periosteally into the symphysis soft tissues was acceptable. For moderate problems where the symphysis was between 10 and 20 millimetres deficient from the Frankfort-Nasion line then an acrylic implant (subperiosteal) was indicated and for the severe cases (greater than 20 millimetres) a retrocondylar implantation was required. (Gonzalez-Ulloa & Stevens 1968).

Bell and Dann (Bell & Dann 1973) noted that the use of silicone rubber implants to bolster the contour of the chin invariably produced some degree of resorption of the underlying bone. They noted that the anterior sliding horizontal body osteotomies were considerably more stable than the implants of silicone, and that the pedicled forward slide (where the genioid muscles were still attached) demonstrated no relapse or resorption whereas the non-pedicled forward slide (essentially a free-bone graft) did show resorption and or relapse. In their summary, Bell and Dann did not recommend the use of silicone for the bolstering of the chin contour.

Feuerstein (Feuerstein 1978) reported a case of using silastic to place a hinged implant that bolstered the inferior aspect of the jaw as well as the anterior aspect of the symphysis.

Snyder et al (Snyder, Courtiss, Kaye & Gradinger 1978) also reported the use of silastic, as a gel in the form of a button with an attached triangular patch of Dacron behind the button. The Dacron patch allowed the button to be sutured to either

the periosteum or the surrounding soft tissues (extra-periosteal) or the bone (subperiosteal). Snyder et al reported that there were two types of buttons, but only reported in detail on the modified (Phase II) type. The original type (Phase I) suffered from many complications such as:

a. Internal soft tissue erosion.

b. External soft tissue erosion.

c. Indentations.

d. Slippage.

e. Asymmetry.

f. Infection.

g. Bone resorption.

The Phase II type suffered only from asymmetry.

Moos et al reported on the use of an alloplastic material called "Proplast", a teflon (fluorocarbon polymer) synthetic with either a porous carbon fibre (grey Proplast I), or a porous aluminium oxide fibre (white Proplast II), that showed moderate success. It satisfied many of the requirements of a synthetic:

1. It was carvable and stable in that shape.
2. It was autoclavable.
3. It was well accepted by the tissues and not cytotoxic.
4. It is not resorbed.
5. Its porosity firmly fixes the implant after six weeks reducing subsequent migration. (Moos, Jackson, Henderson & Gibbs 1979.)

A total of 14 cases of chin augmentation were treated;

11 intra-orally placed

(6 subperiosteal and 5 extra-periosteal)

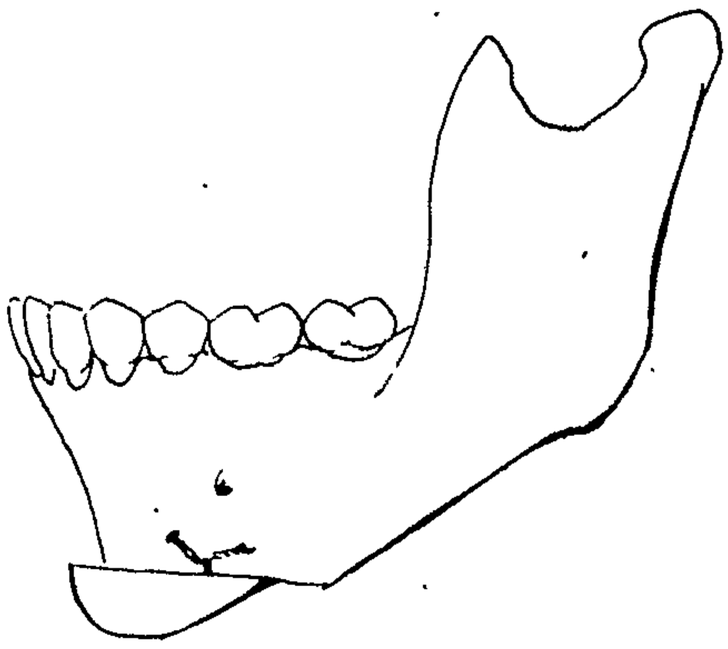
3 extra-orally placed

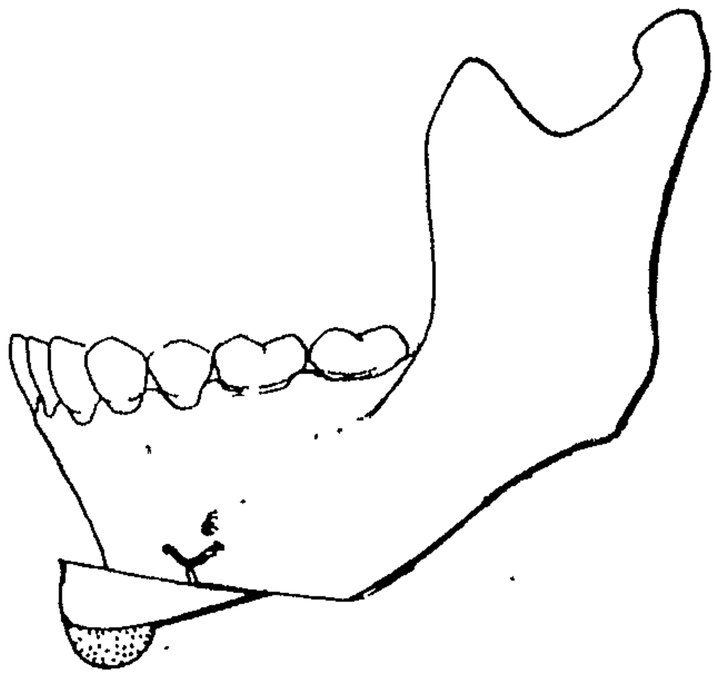
(all extra-periosteal).

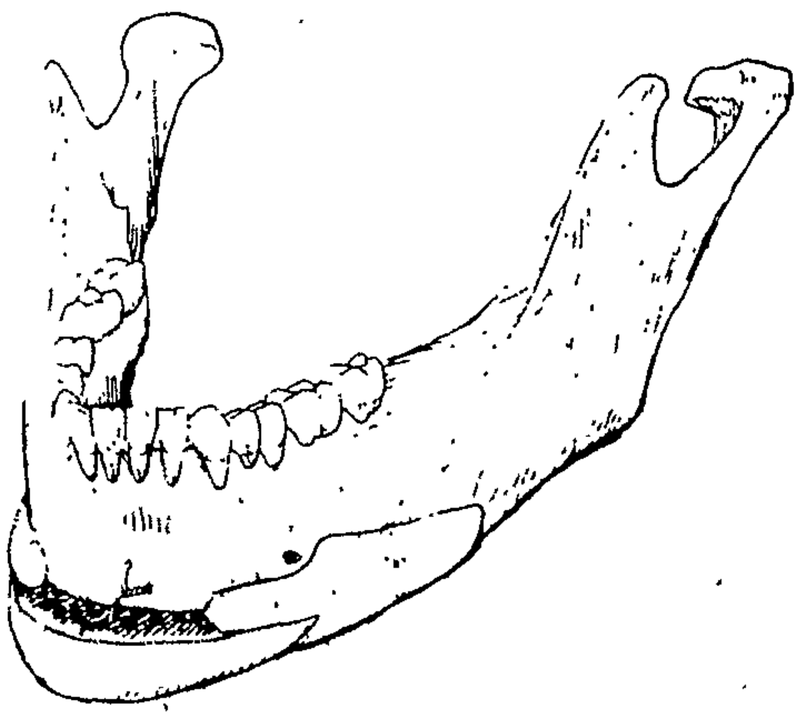
The results were satisfactory as regards contour, colour, stability, implant margin and infection. Other areas were investigated but are beyond the scope of this treatise. (Moos, Jackson, Henderson & Gibbs 1979.)

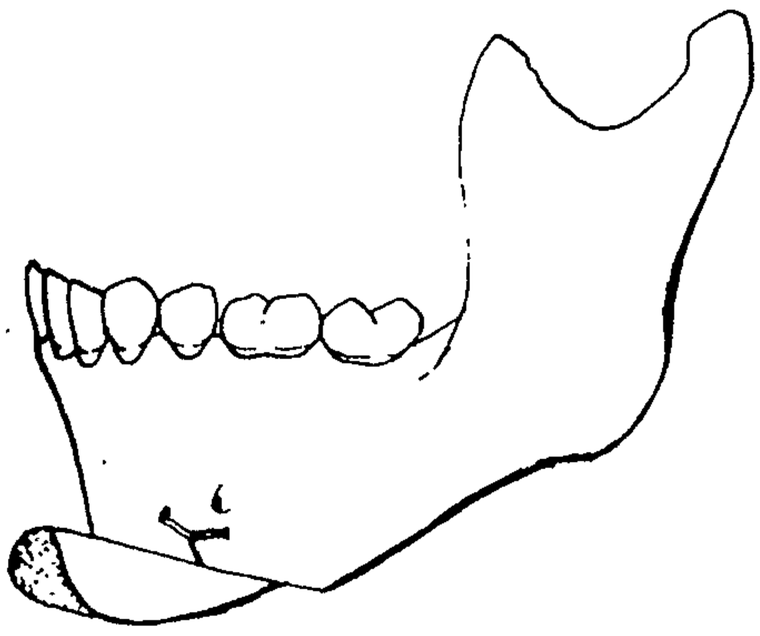
A further report in 1981 by Kent et al. (Kent, Westfall & Carlton 1981) was a long term study of the stability of Proplast. This group used an intra-oral approach and placed antibiotic impregnated Proplast at the symphysis. The Proplast was held in place using resorbable sutures, attaching the Proplast to either muscle, or periosteum or both. The augmentations were followed up for a period of twelve months to ninety six months. Their findings were that the Proplast is a satisfactory implant material with just under half the implant resorbed after one year and slightly more resorbed by the second and third years to bring the total resorbed material to just over half. There was no further shrinkage/resorption. Kent et al were happy with this as there were no other long term post-operative problems with the implants.

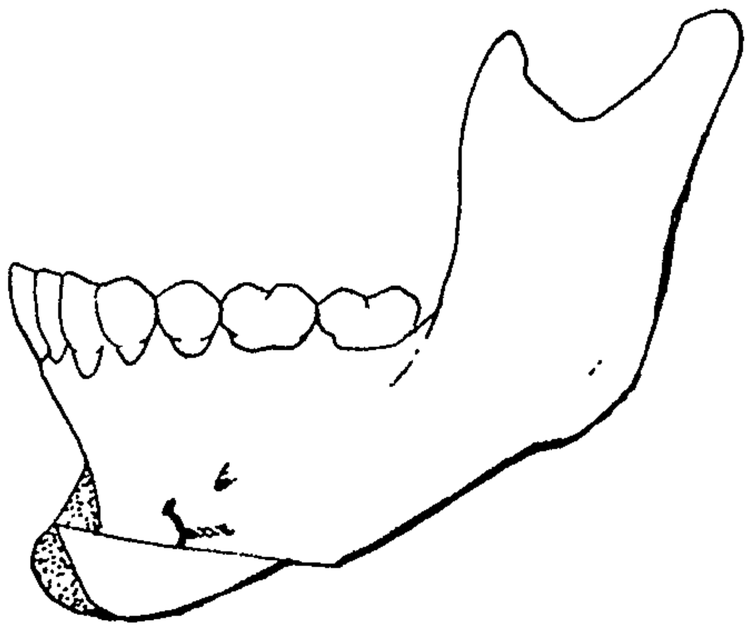
While the most common use for synthetic material is to bolster the antero-posterior dimension, they can also be used to increase other dimensions such as the vertical dimension as well as augment other procedures. Bell et al (Bell, Proffit & White 1980) using antibiotic impregnated Proplast described several variations for the use of Proplast to supplement augmentation osteotomies of the symphysis. The Proplast was used both vertically and antero-posteriorly by extending the graft down past the lower border to hook under the lower border, and also to simply fill in











Bell, Proffit & White's Variations on the Use of "Proplast" at the Symphysis. From Bell, Proffit & White 1980.

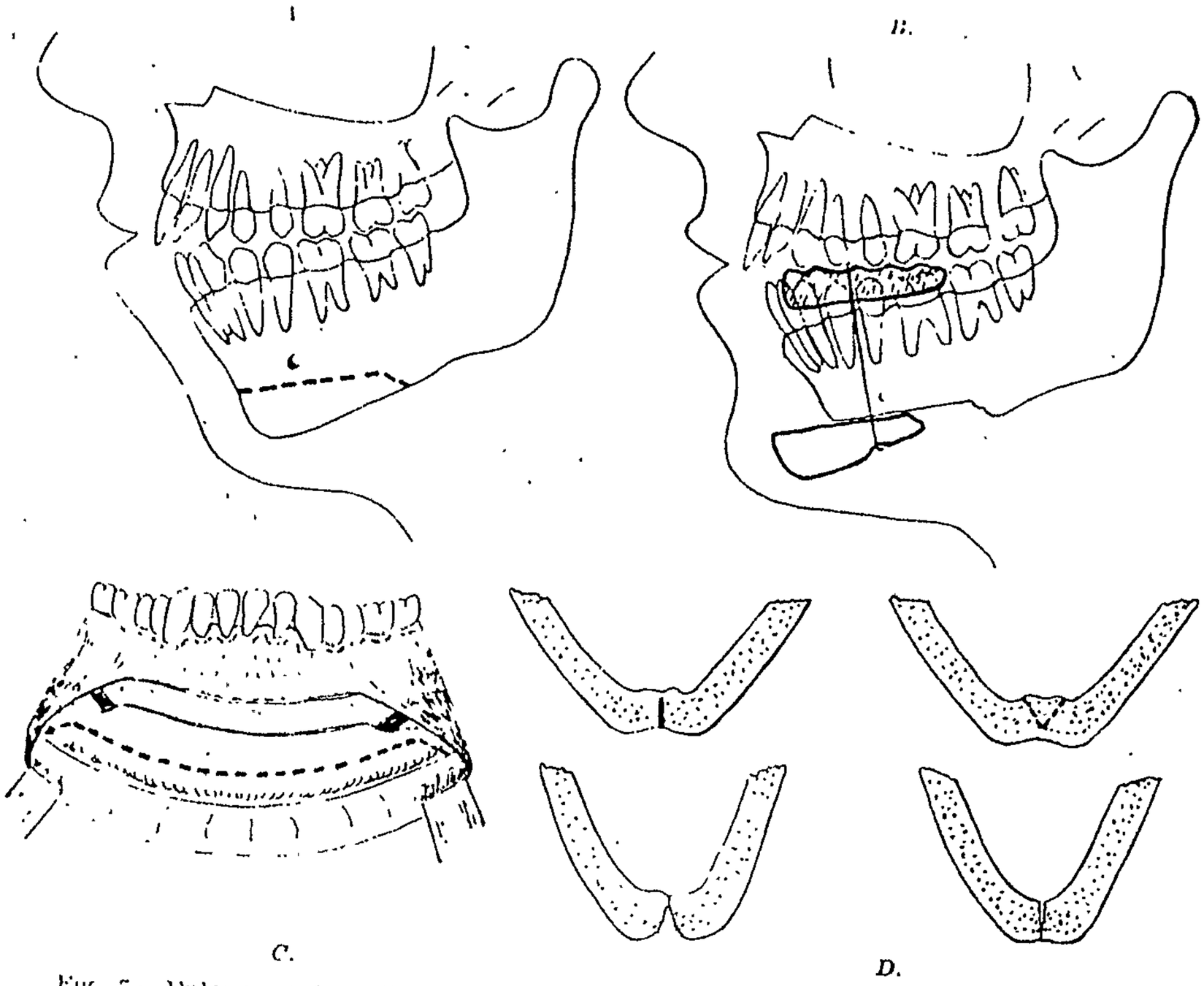
Diagram 142

deficiencies remaining after symphysis procedures to produce a smoother contour. See **diagram 142.**

A disadvantage of synthetic onlays is that should any of the teeth under the onlay develop an abscess and require apicectomy then the onlay may have to be removed to access to the apex of the tooth. As well there would be the problem of infection and a foreign body. (Trauner & Obwegeser 1957).

Development of Horizontal Body Genioplasties.

In the 1950's Trauner and Obwegeser were refining mandibular body surgery still further to produce a series of genioplasty techniques to correct deficiencies of the chin. (Trauner & Obwegeser 1957). The procedure was based on an original procedure of Hofer (Hofer 1942) who recommended that the procedure be performed by an extra-oral approach. The procedure required the protrusion of the lower border, leaving the body of the mandible in its original position, basically untouched. See **diagram 143.** Viewed in profile, the symphysis was sectioned into two at the horizontal plane, and the inferior portion taken forward. The occlusion remained the same. Later surgeons (Converse 1963 and Neuner 1973) preferred to keep the muscle and periosteum attached to the advancing fragment. This helped ensure the viability of the advanced fragment. Obwegeser and Trauner went to pains to ensure that the advanced fragment was free of any attachments. Bell and Dann (Bell & Dann 1973) in personal communications to Epker and Steinhäuser noted that where the inferior fragment was advanced as free bone then significant resorption was noted. Where the inferior fragment was advanced still pedicled to the lingual tissues, then no resorption was noted. However long term studies and comparisons have not been done.



C. D.

Fig. 7.—Enlargement of the chin by sliding forward a horseshoe-shaped piece of bone of the lower border of the mandible by an intraoral approach. *A*, Mierogenia (dotted line shows bone cut). *B*, The horseshoe-shaped bone slid forward. It is held in position by circumferential suturing on both sides tied over a bite-raising splint. It is in broad contact with the mandible. *C*, Chin area exposed intraorally (dotted line indicates bone incision). By incising the anterior cortical plate (*D*) a slightly broader and by cutting out a wedge-shaped bone on the lingual side (*E*), a slightly narrower chin is formed when the protruding ends are approximated.

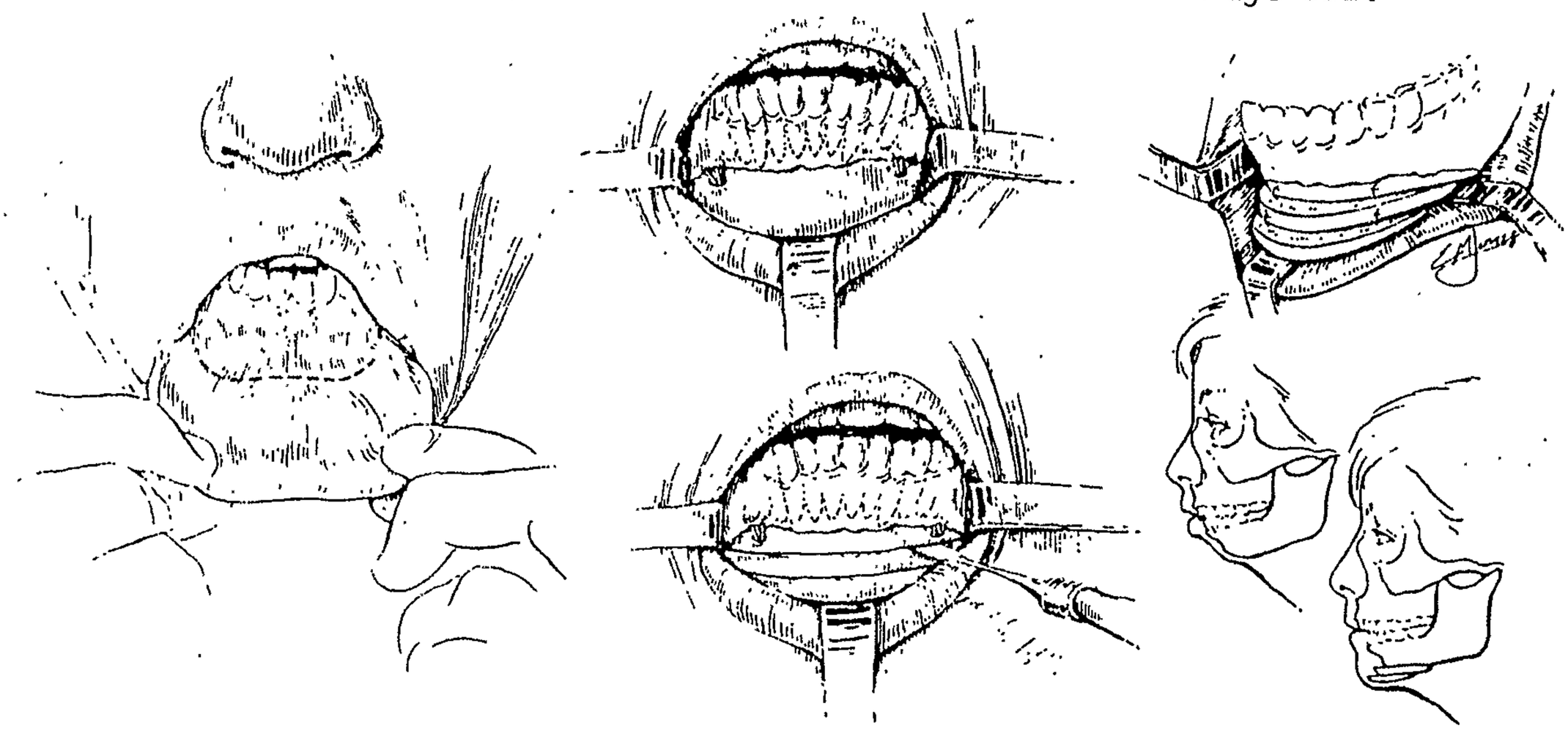
Trauner & Obwegeser's Horizontal Body Osteotomy 1955.

From Trauner & Obwegeser 1957.

Diagram 143

Obwegeser and Trauner used a "degloving" procedure to achieve the horizontal section. A horizontal buccal mucosal incision is made extending from first molar to first molar. The mentalis muscle is cut leaving sufficient insertion to allow resuturing, and then the periosteum is raised. This approach allows access for a number of procedures, not only for the horizontal body osteotomy. See **diagram 143.**

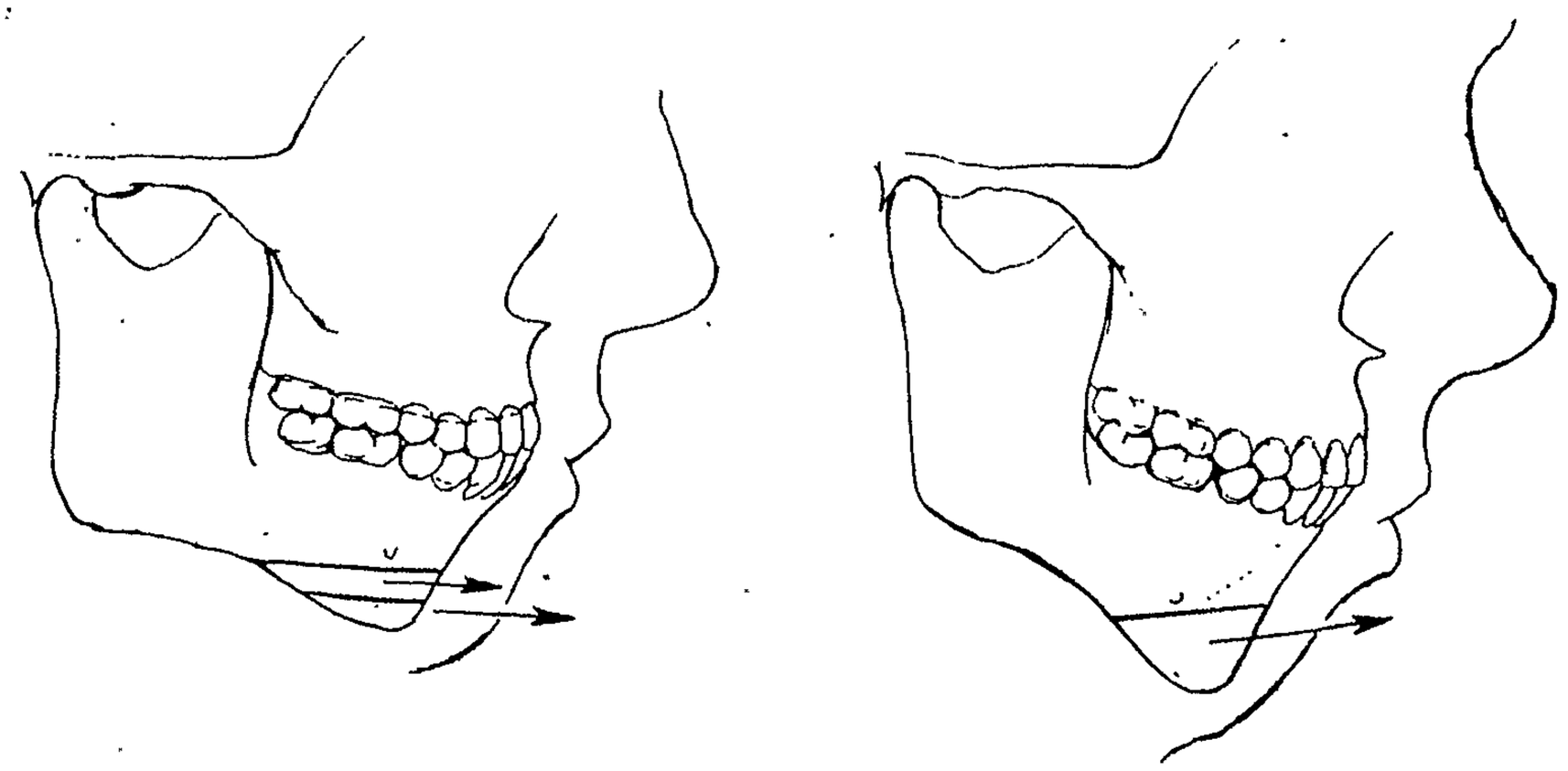
Further refinements by Obwegeser (Obwegeser 1971;



Trauner & Obwegeser's Multi-layered Shifts of the Horizontal Body Osteotomy 1971.

From Lawson & Binder 1978.

Diagram 144



The Double Layer Horizontal Body Osteotomy. and the Oblique Horizontal Body Osteotomy. From Epker & Wolford 1980.

Diagram 145

1973) allowed a multi-layered shift to take place to produce a greater degree of protrusion of the chin with a greater degree of stability. The procedure was the same as the the horizontal symphysis osteotomy except two horizontal sections were performed. See **Diagram 144.** The multi-layered effect was done by sectioning the symphysis at several heights in the vertical plane to produce a number of "sandwiches" of bone. The "sandwiches" were then stepped forward until the required amount of protrusion was achieved. The procedure had the advantage of being able to achieve a greater degree of protrusion than the single stage horizontal osteotomy. Within the limits of the bone available, the greater the number of layers the further the amount of protrusion that could be obtained. (Obwegeser 1973). While Obwegeser only demonstrated a two layer shift, as did others since (Lawson & Binder 1978), a triple layer shift was subsequently performed, (Neuner 1973).

Schuchardt, in a personal communication to Converse (Converse & Wood-Smith 1964) said that the technique had been written up before in the German Literature. However it was not made clear whether the procedure had been written up before by the same authors (Trauner & Obwegeser), or whether by other authors.

Neuner (Neuner 1973) achieved further advancement capability by producing double and triple layer shifting. Neuner achieved as much as 3 centimetres of anterior shift.

Epker & Wolford (Epker & Wolford 1980) recommended that the digastric muscles be detached from the lower border (most inferior) segment, but the genioid muscles be left attached to allow adequate blood supply. Detaching the digastric muscle allows freer

forward movement of the pedicled inferior fragment.

General Indications in Microgenia Procedures.

Converse (Converse 1963) defined those chins that could be classified as microgenic without being micrognathic as having

1. Relatively small mandible.
2. An underdeveloped chin.
3. A characteristic occlusion where the lower incisors are lingual to the upper incisors and in marked overbite.
4. There is a diminishing of the lower third of the face.

Gradually the indications for the use of procedures for correction of microgenia were being defined. In patients with moderate microgenia the following procedures could be employed:

A. A bone graft over the symphysis done routinely through an intra-oral approach. (Converse 1950)

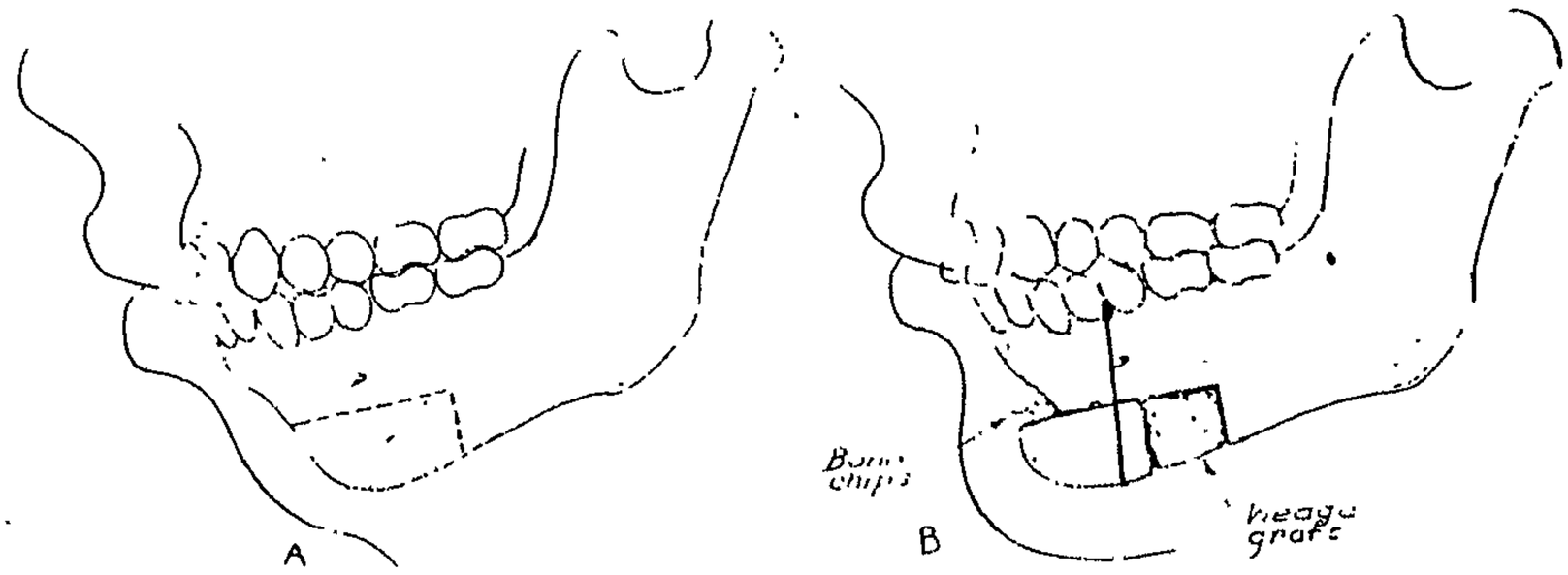
B. A synthetic implant material over the symphysis. (Brown et al 1960)

C. Horizontal osteotomy of the body of the mandible (Obwegeser & Trauner 1957)

D. Combination of bone graft and horizontal elongation where the mental region tissues are more tense than normal. Such a situation could result from burns. No cases were cited. (Converse 1963)

E. Retrocondylar implantation (Babcock 1937 and later Trauner & Obwegeser 1957)

Converse (Converse & Wood-Smith 1964) updated the



The line of step horizontal osteotomy of the body of the mandible *B*, after advancement of the inferior portion of the mandible and stabilization of the advanced segment by means of a wedge of iliac bone in the posterior defect, and a circumferential wire passing through a drilled hole in the advanced mandibular segment. Additional contour restoration is obtained by packing bone chips along the superior border of the advanced segment.

The Step Horizontal Body Osteotomy.
From Converse & Wood-Smith 1964.

Diagram 146

list of possible procedures given the previous year by including procedures that could change the shape of the mandible as well as correct chin deficiency with or without changing the occlusion. They were all variations of the horizontal body osteotomy of Trauner and Obwegeser:

A. Sliding Oblique Horizontal Osteotomy.

The difference between this procedure and the horizontal body osteotomy is that the section is not parallel to the lower border of the mandible. The approach is intra-oral using a "degloving" technique as described by Trauner and Obwegeser. Fixation is by the use of circumferential wires at the symphysis which are removed at the termination of the fixation period. The inferior fragment is moved anteriorly to correct the deficient chin. The procedure is best suited for those cases that show a short ramus, an obtuse gonial

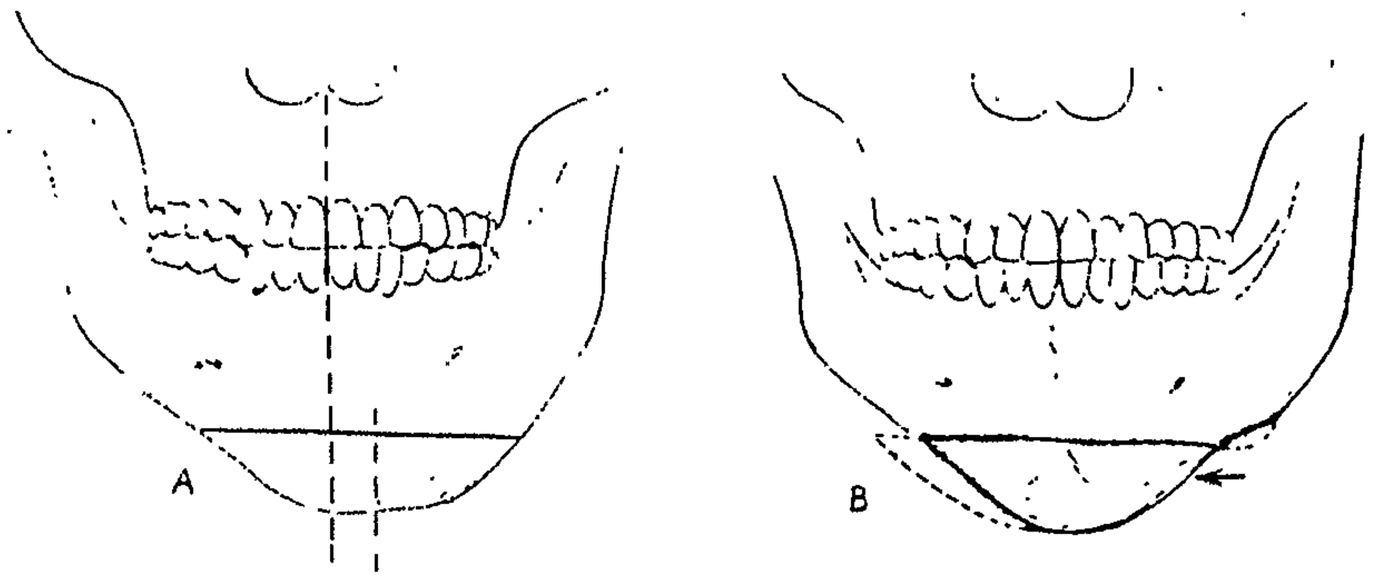
angle and a steep, straight mandibular/occlusal plane. The procedure can reduce the vertical dimension of the face. See **diagram 145.**

B. Step Horizontal Osteotomy

The section cut is made higher than the oblique horizontal osteotomy and not at an oblique angle as used on the above oblique osteotomy. Immediately in front of the mental foramen, the section is continued vertically downwards to finish on the lower border. A wedge of iliac crest bone can be used (not always necessary) to fill in the gap between the advanced segment and the body of the mandible. The inferior fragment is advanced anteriorly. Advancement is more stable due to the use of the bone graft to help with more rapid healing. As well bone grafts can be used to correct any further deficiency of the mandible in the area of operation. Fixation is with the use of either circumferential wiring or interosseous wiring. The procedure is indicated where there is a normal gonial angle, a normal mandibular/occlusal plane and the vertical dimension is satisfactory. The chin itself is deficient in the antero-posterior dimension. See **diagram 146.**

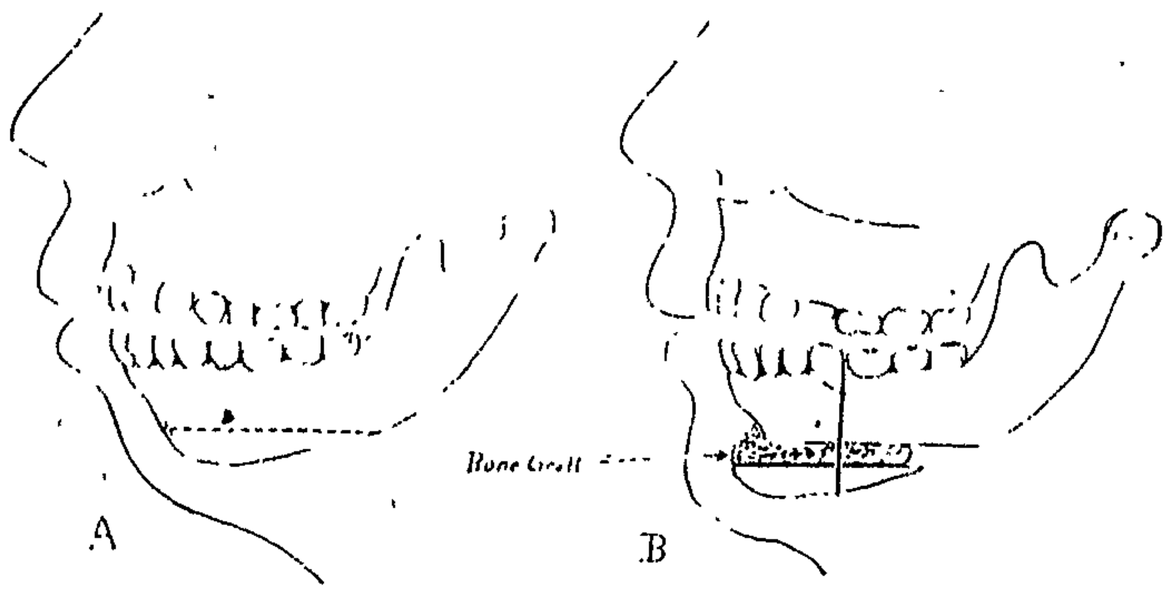
C. Horizontal Osteotomy with Lateral Shift

Also see Asymmetry Chapter. The surgical technique is the same as described in "A." except the inferior fragment is shifted laterally rather than anteriorly. It is important to score the facial midline in the bone so that the inferior fragment can be properly localised laterally when shifted. A clinical "eye" is not always sufficient. Excess bone may be trimmed or a graft added to further bolster the correction. This procedure is best used where the asymmetry is localised in the symphyseal region, and where the occlusion and the body of the mandible is otherwise adequate, and with the exception of



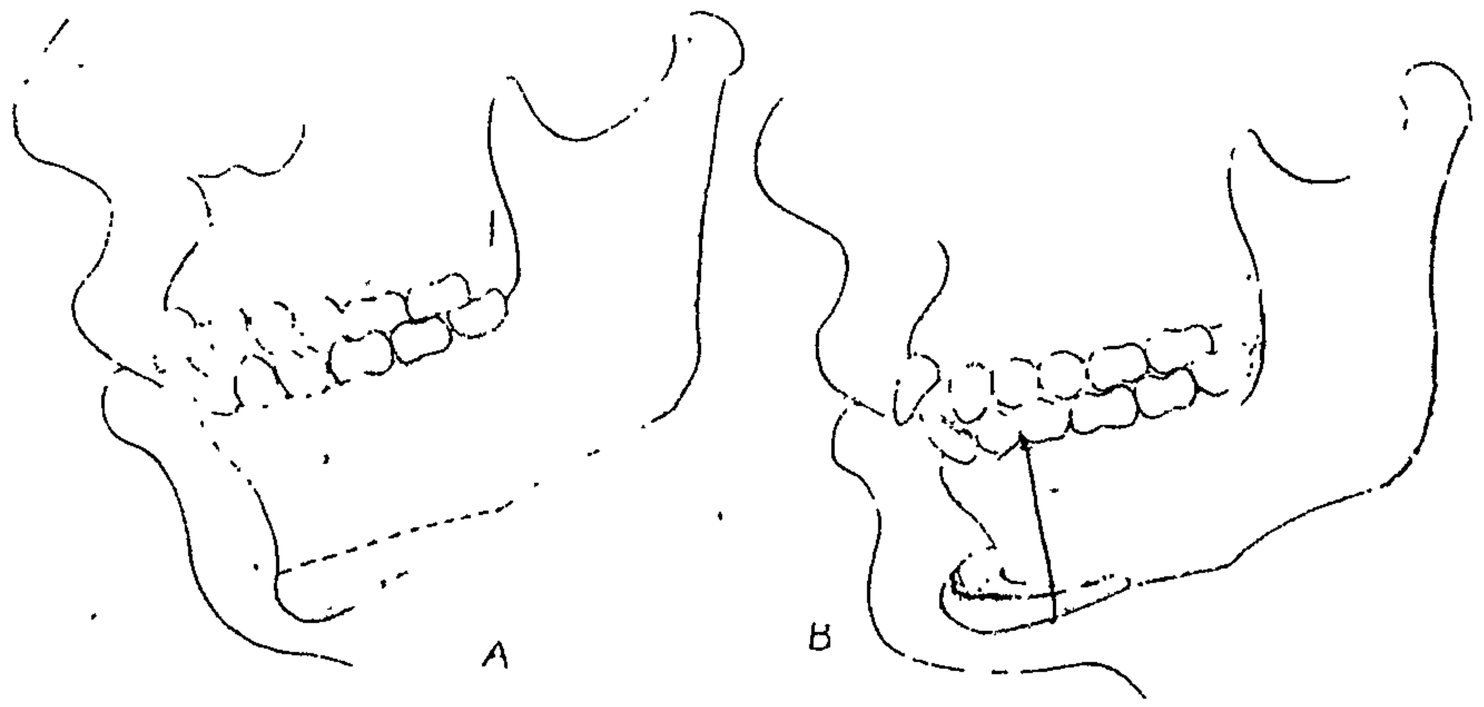
A, the line of horizontal osteotomy in mandibular asymmetry with adequate dental occlusal relationships. *B*, the mobilized segment is shifted laterally in order to bring the midpoint of the chin to a position corresponding to the midsagittal plane of the face. Excess bone is removed laterally to achieve symmetry.

The Lateral Shift Horizontal Body Osteotomy.



A, Horizontal section of the body of the mandible. *B*, Interposition of a bone graft in order to increase the vertical dimension of the body of the mandible: the "sandwich" operation. Fixation is provided by a circumferential wire on each side.

The "Sandwich" Graft Horizontal Body Osteotomy.



A, the line of horizontal osteotomy of the mandible in a patient with excess vertical dimension of the body of the mandible. *B*, the excess inferior segment of the mandible is completely freed of periosteum and muscle insertions on its anterior, inferior and posterior aspects and, if necessary to correct a microgenic appearance, may be transplanted over the anterior aspect of the inferior portion of the mandible and fixed in position by means of a circumferential stainless steel wire; in many instances the excess bone may be discarded.

Converse & Wood-Smith's Horizontal Osteotomy of the Body to Reduce the Vertical Dimension and Increase the Anterior - Posterior Dimension.

All of the Above Diagrams from Converse & Wood-Smith 1964.

Diagrams 147, 148 & 149

the symphysis, has good contour. See **diagram 147.**

D. "Sandwich" Horizontal Osteotomy with Vertical Shift

The same procedure as in "A." except there is an interposed graft of iliac crest bone or Proplast (Henderson 1981) between the two fragments that has the affect of extending the inferior fragment inferiorly. Fixation is achieved with circumferential wiring which is removed at the conclusion of fixation. While circumferential wiring is usually necessary with "sandwich" procedures, it must be removed at the end of the fixation period. Interosseous wiring of the fragments is always preferable where possible as this type of fixation is more stable and usually does not require removal post-fixation. See **diagram 148.**

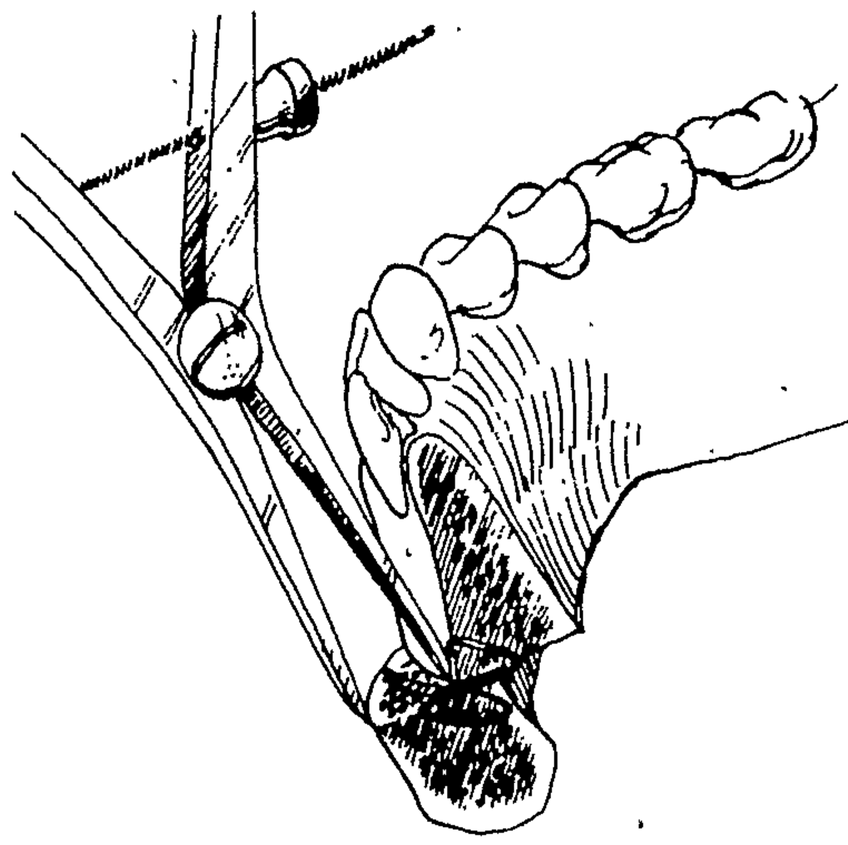
E. Horizontal Osteotomy and Resection with Vertical Shift

Where the vertical dimension of the lower third of the face is excessive, and the deformity lies predominently in the symphysis region. The procedure is performed as in "A." except the inferior fragment is discarded to reduce the height of the symphysis.

F. Horizontal Osteotomy with Vertical and Horizontal Shift

The same as in "D." except the resected fragment is utilised to bolster the contour, for example, in the anterior part of the symphysis. This may be indicated in people who have an obtuse gonial angle. The chin shape is normal but has too much extension inferiorly and insufficient extension anteriorly. See **diagram 149.**

Converse recommended the body sliding technique for the correction of genial problems not only by itself but also in combination with other procedures for the total correction of



Epker & Wolford's Figure 8 Wiring of Symphysis Fragments.
From Epker & Wolford 1980.

Diagram 150

mandibular or facial deformity. Converse recommended that the surgery site be stabilised by the application of circumferential wires, and a moderately firm pressure bandage to the chin which also helps reduce the incidence of haematoma formation. The wires are is removed after four to six weeks, and the pressure bandage after one week. Later authors such as Epker and Wolford (Epker & Wolford 1980) have preferred the use of direct interosseous wiring rather than circumferential wiring as this type of wiring is more stable and does not require removing unlike circumferential wiring. The interosseous wiring is usually figure 8 wiring with the lingual plate of the inferior fragment wired to the labial plate of the superior fragment. See **diagram 150.**

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MANDIBULAR SYMPHYSIS DEFORMITIES

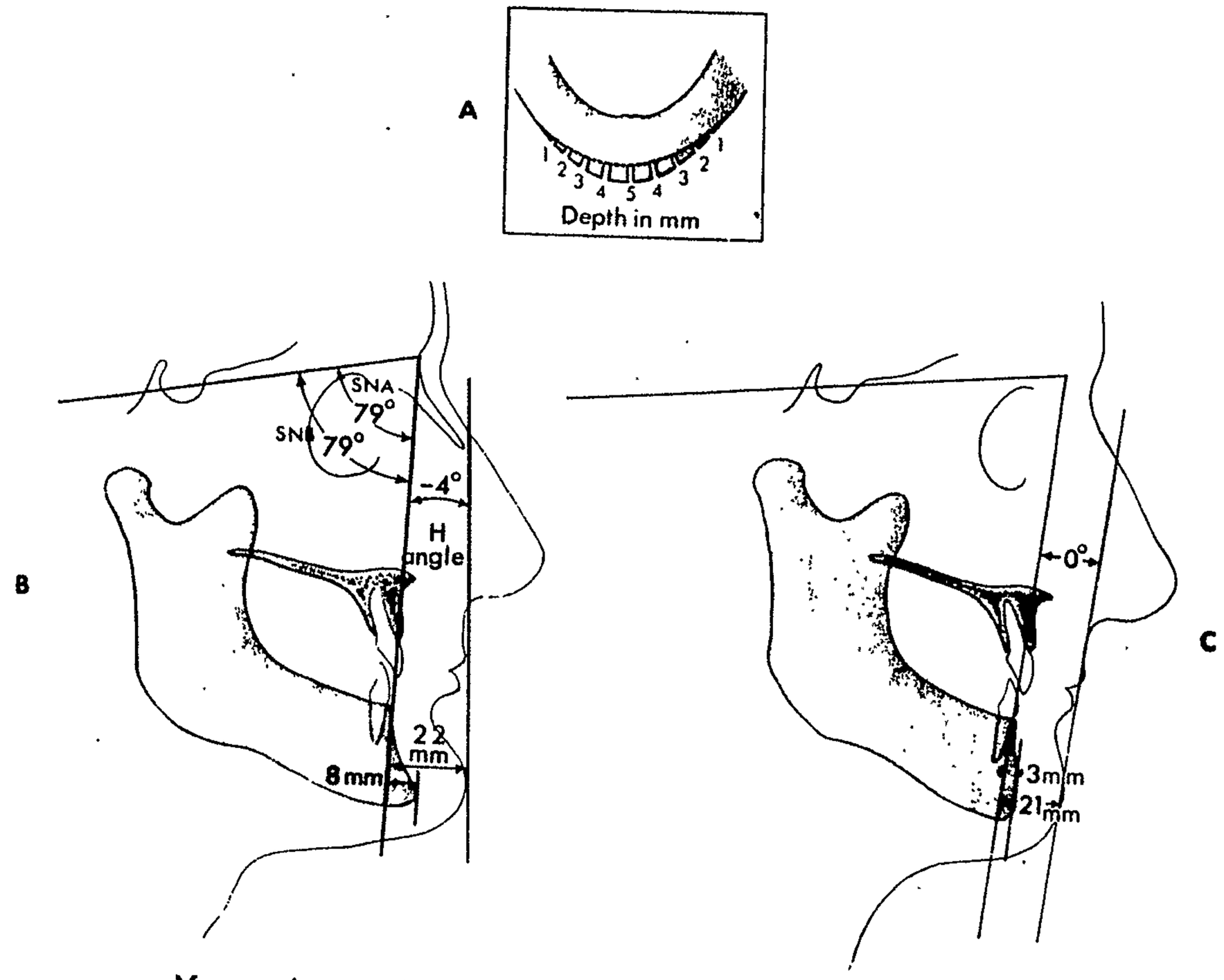
Macrogenia Procedures

Development of Body "Shave" Genioplasties.

There has been little written about simple reduction genioplasties, despite the simplicity of the procedures compared to more sophisticated genioplasty procedures such as the body osteotomies. Some authors (Hinds & Kent 1972, Epker & Wolford 1980) attribute this to the variability of the results when simple shave procedures are used. See **diagram 151.** Body shave procedures were developed for the treatment of asymmetry. Hence they are discussed in more detail in the Chapter on Asymmetry. Symphysis shave procedures are no different in technique to the body shave procedures, but are different in the effects of the treatment on the soft tissue outline post-operatively. The loss of cortical bone producing uneven resorption and loss of cortical plate contour. These differences are such that currently most surgeons will not perform a shave procedure of the symphysis, nor will many deglove the symphysis when a reduction procedure is to be performed. However this aspect of degloving is still in dispute between surgeons.

Development of Horizontal Body Genioplasties.

Hinds and Kent (Hinds & Kent 1972) acknowledged the problem of unpredictable soft tissue retraction when the bone was retruded posteriorly, and also mentioned the desirability of keeping the soft tissue attachments of the symphysis when reducing the symphysis. Hinds and Kent used a degloving approach without stripping the symphyseal attachments. They sectioned the symphysis just below the level of the apices of the teeth at the appropriate



Macrogenia—symphysis shaved 5 mm., **A,** but actual reduction in soft tissue was less as measured from line **NB. B,** Preoperative profile. **C,** Postoperative profile.

A Symphysis "Shave" Osteotomy.
From Hinds & Kent 1972.

Diagram 151

angle to the mandibular inferior border and then retruded the symphysis posteriorly and inferiorly. See **diagram 152.** An immediate post-operative pressure dressing was recommended, followed by a chin strap. Hinds & Kent recommended that the lingual tissues be left attached to maintain blood supply and minimise resorption.

Where the macrogenia was a vertical deformity rather than antero-posterior, then either a "wedge" horizontal osteotomy of the body as described by Hinds and Kent (Hinds & Kent 1972), see **diagram 153,** or a "sandwich" horizontal procedure with the excess removed as a layer can be performed as described below by

Epker and Wolford.

Epker and Wolford (Epker & Wolford 1980) recommended that all reduction genioplasties not be done using an oral degloving procedure and removing the required amount of bone from the symphysis as this often provided poor and unpredictable results. While the bony shape was the required one, the accompanying soft tissue profile was not. The soft tissue would often only slightly change, and sometimes would even increase in thickness. Epker and Wolford advised that any bone be reduced from between the apices of the teeth and the symphysis, with the symphysis retaining all attached soft tissues, thus the soft tissue would retreat with the reduced bone. Only that amount of soft tissue stripping required to expose the area of surgery and provide adequate access was recommended. The excess bone was removed, using a subapical osteotomy approach, as a reverse 'sandwich' procedure. The fragments were then direct wired together.

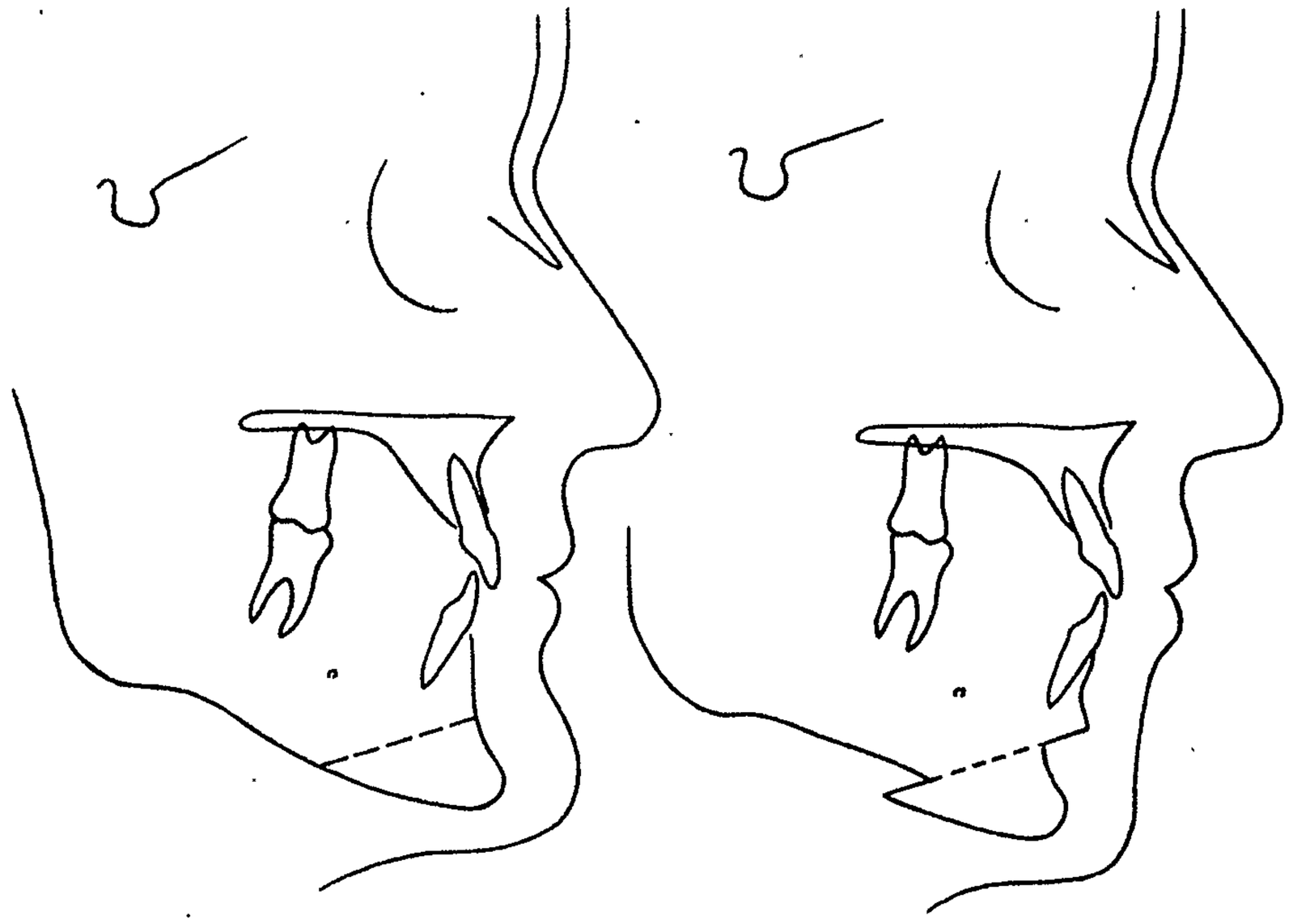
Earlier Epker (Hohl & Epker 1976) in a review of macrogenia, classified macrogenia problems into those that were essentially vertical in nature and those that were essentially anterior in nature, and those that were a combination. See **diagram 154.** Their surgical findings are summarised below:

1. Anterior Macrogenia. **Diagram 155**

   A. As mentioned previously, it was noted in the review that the simple chin "shave" was unsatisfactory.

   B. A vertical ostectomy was proving to be satisfactory, producing reliable 1:1 hard to soft tissue changes.

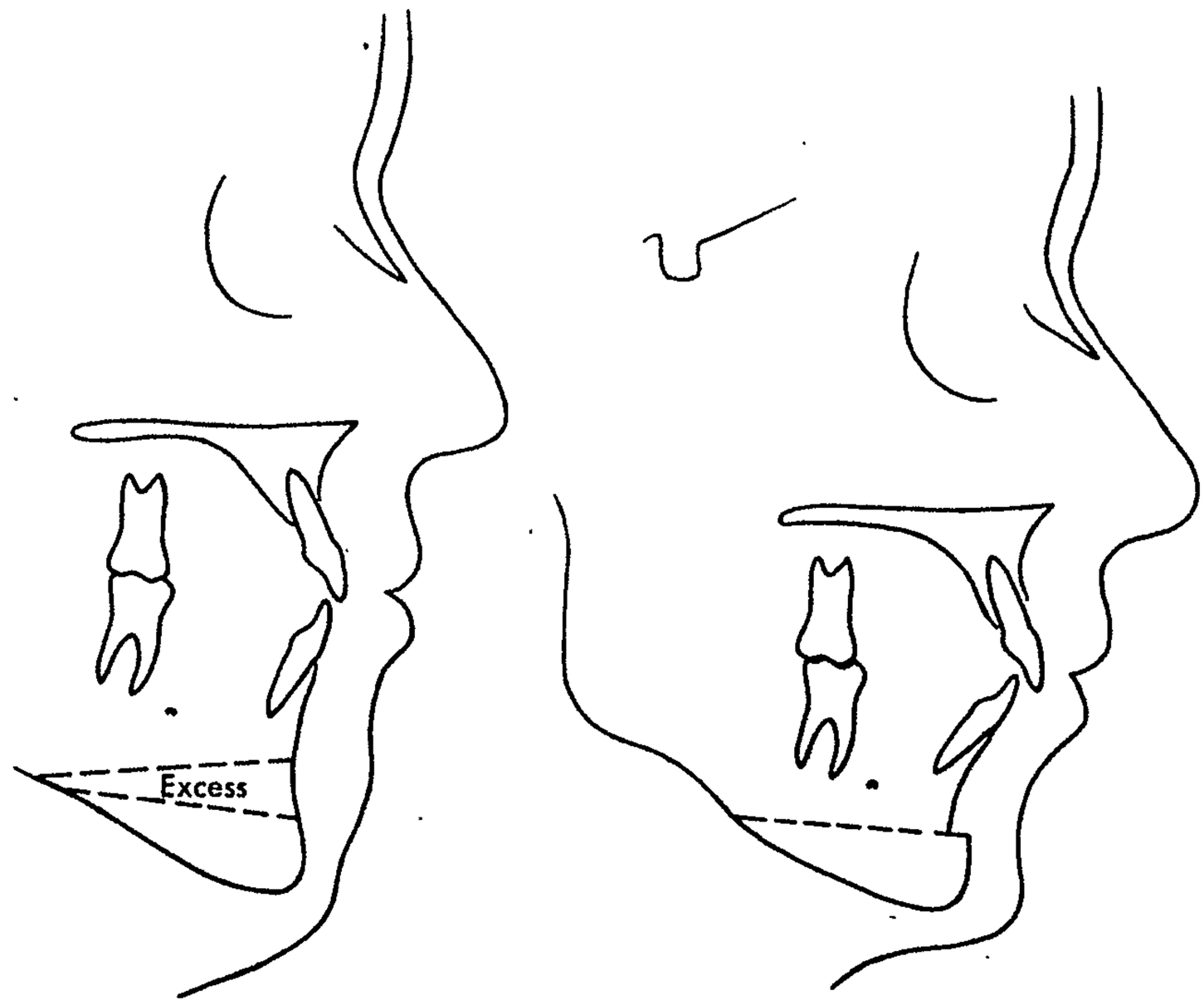
   C. An oblique sliding horizontal osteotomy and this was also proving to be satisfactory for the same reason.



Macrogenia corrected by sliding osteotomy.

Hinds & Kent's Oblique Horizontal Body Osteotomy for Correction of Antero-posterior Macrogenia. From Hinds & Kent 1972.

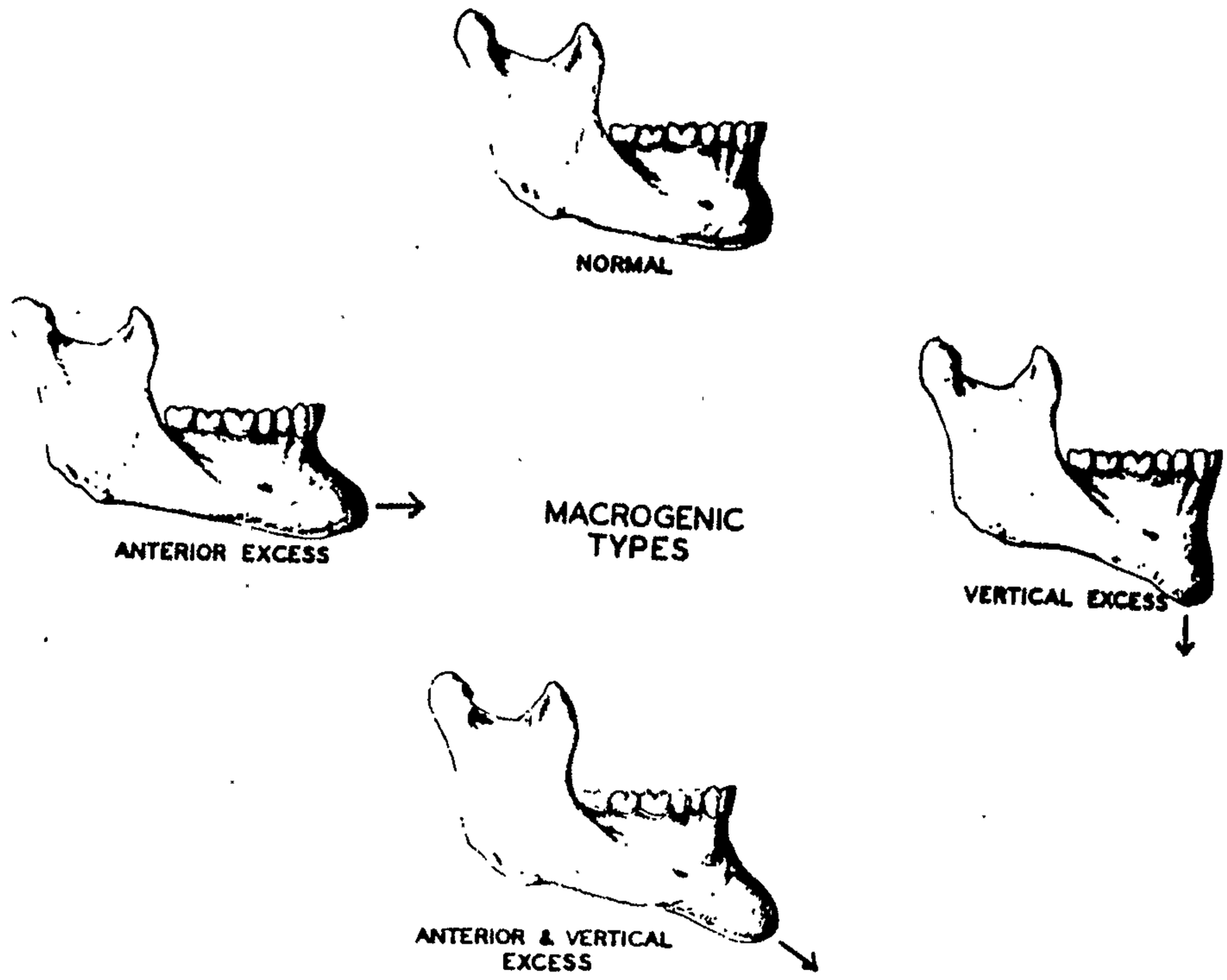
Diagram 152



Wedge ostectomy is indicated when vertical dimension is too great.

Hinds & Kent's Wedge Symphysis Osteotomy for Correction of Vertical Macrogenia. 1972.

Diagram 153



Classification of osseous macrogenia into three types.

From Hohl & Epker 1976.

Diagram 154

2. Vertical Macrogenia. **Diagram 156**

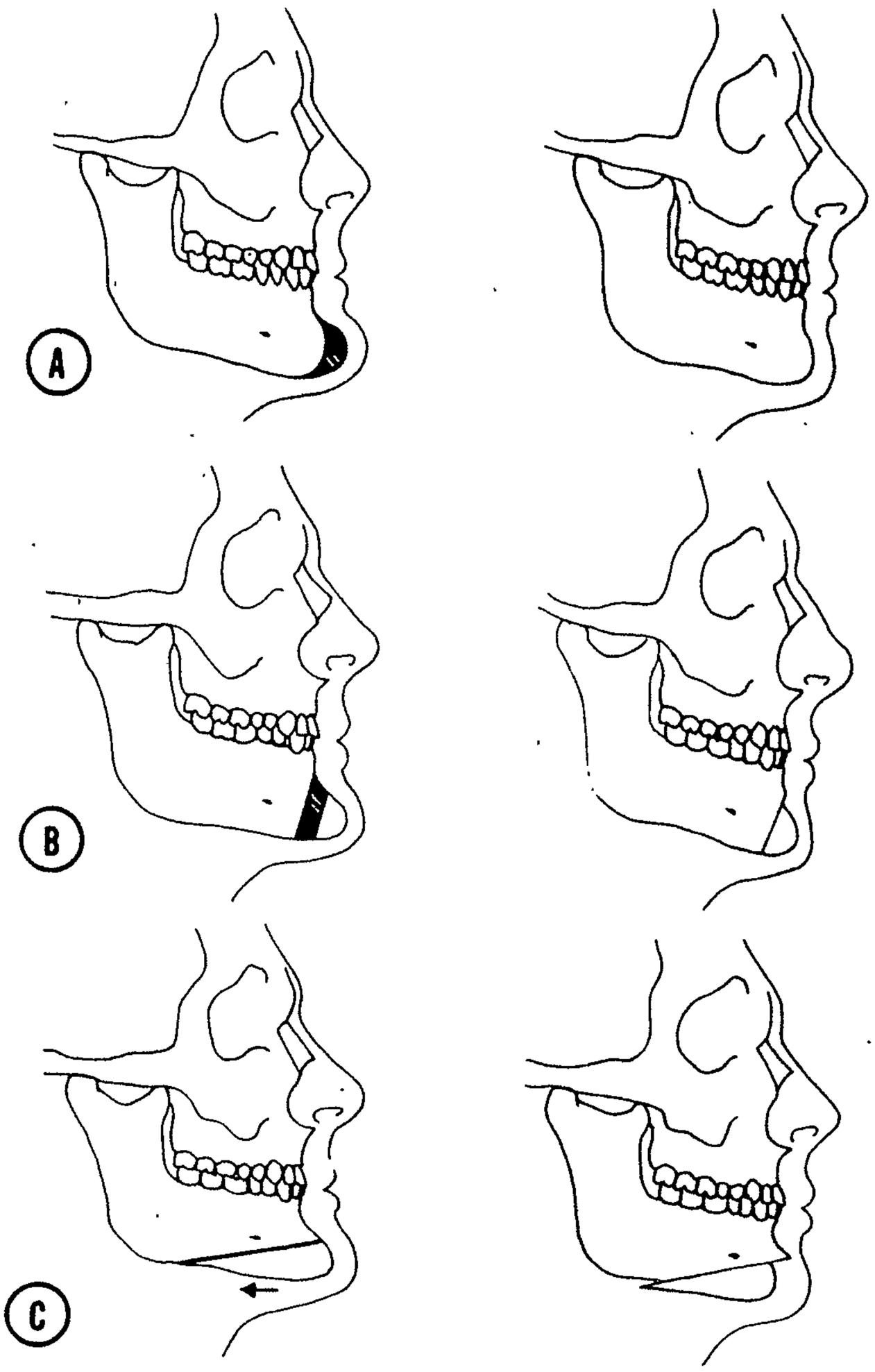
   A. A lower border shave which was proving unsatisfactory with hard to soft tissue changes of approximately 3:1.

   B. An oblique horizontal ostectomy, with the removal of a "sandwich" of bone and superior resiting of the lower border. No comment was offered.

   C. Converse's inferior border free graft. This was no longer preferred, instead the lower border is repositioned as a pedicled graft.

3. Combination Macrogenia. **Diagram 157**

   A. An oblique ostectomy could be carried out as a "shave" procedure, with the angle of the section proportional to the degree of combination of anterior and



Surgical techniques for anterior macrogenia.

From Hohl & Epker 1976.

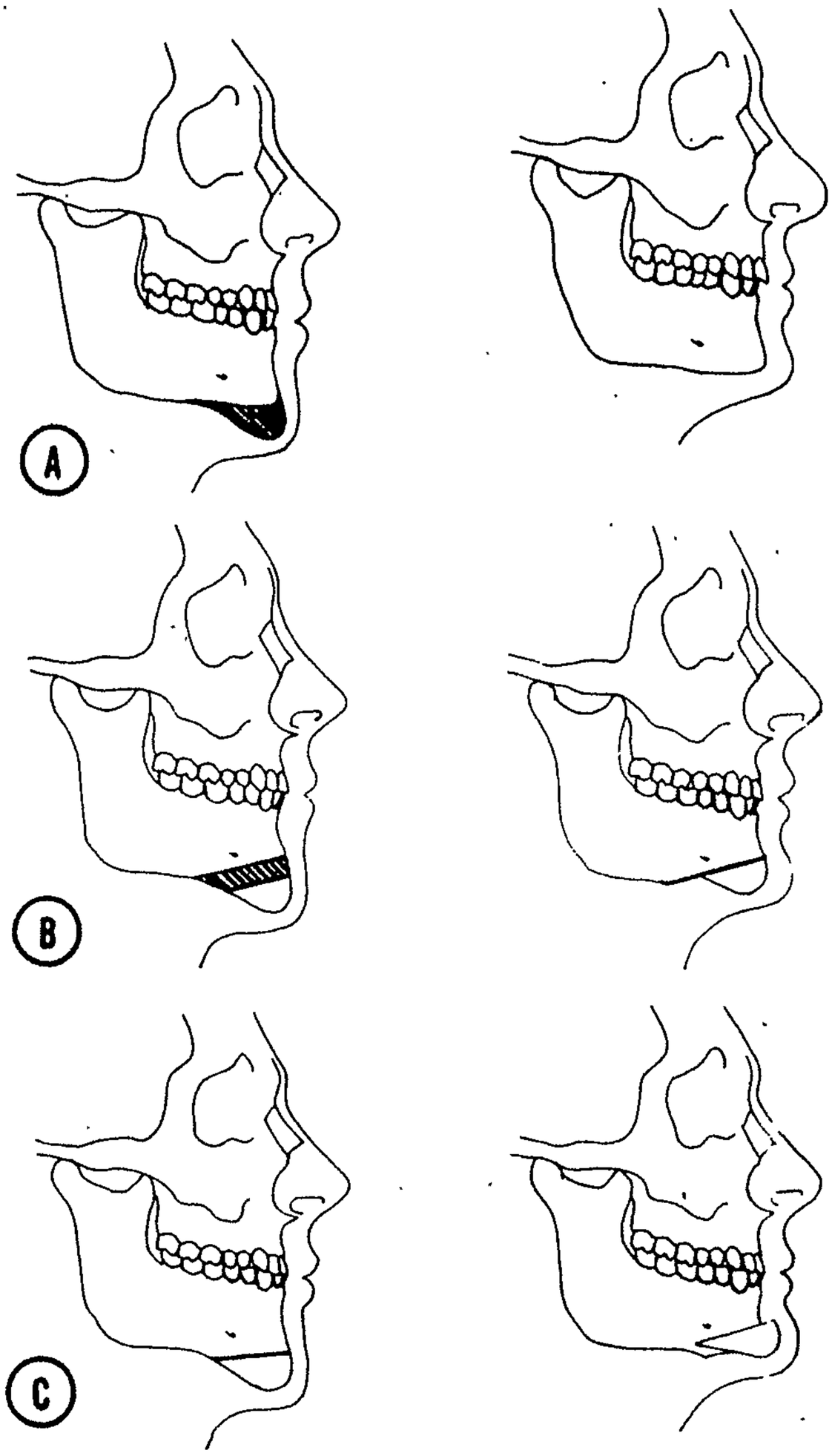
Diagram 155

vertical components. This was no longer recommended for reasons already mentioned above.

B. An oblique horizontal osteotomy with the angulation of the obliquity determined by the anterior and vertical growth components. Then a "sandwich" of bone is removed.

C. An oblique horizontal osteotomy of the symphysis with a wedge of bone removed instead.

Both B. and C. were preferred by the surgeons where the symphysis



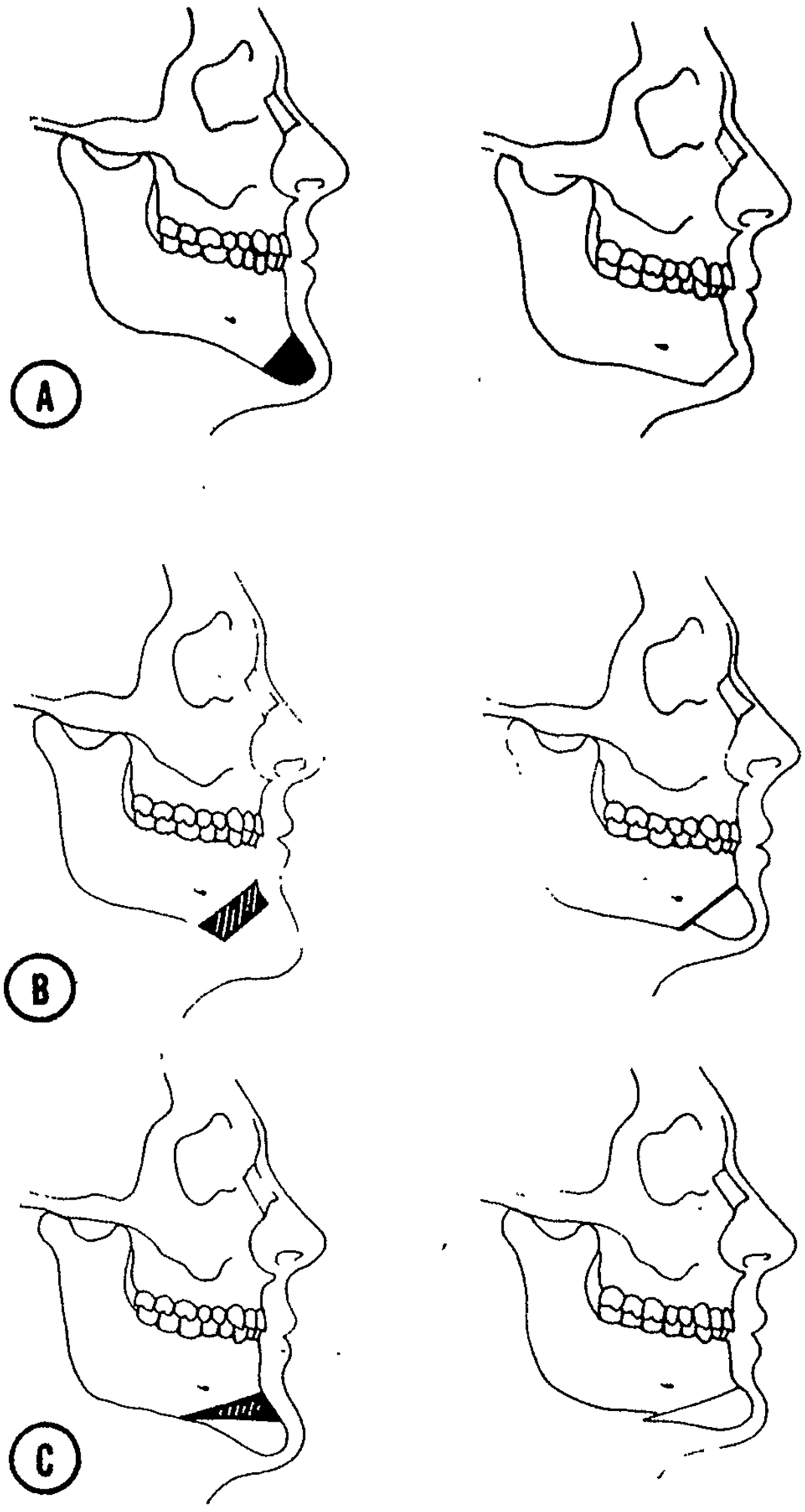
Surgical techniques for vertical macrogenia.

From Hohl & Epker 1976.

Diagram 156

fragment is still pedicled.

Bell et al (Bell, Brammer, McBride & Finn 1981) also demonstrated the use of the horizontal body osteotomy for the correction of macrogenia antero-posteriorly. The operation varied little from that described by Obwegeser and Trauner, and later



Surgical techniques for anterior and vertical macrogenia.

From Hohl & Epker 1976.

Diagram 157

Converse, except that the inferior segment was retruded and not advanced. The procedure, in distinction to that of Epker & Wolford, used a degloving procedure. The fragments were wired directly rather than the circumferential wire favoured by Converse.

The amount of the "sandwich" of bone removed, and

the angle of the body osteotomy is determined by the shape of the chin and the desired degree of correction. It follows that some horizontal osteotomies will be oblique to the mandibular plane, and that the inferior fragment will also be retruded, protruded, intruded or extruded, or a combination.

Indications for the surgery performed by Bell were normal to adequate occlusion, slightly increased lower third facial height, prominence of the chin/symphysis. Contra-indications were minimal to nil labiomental fold, and any decrease in lower third facial height.

Development of the Sagittal Symphysotomy.

Super and Guernsey (Super & Guernsey 1977) noted the limitations of the horizontal body osteotomy for the correction of either macrogenia or microgenia. They noted that:-

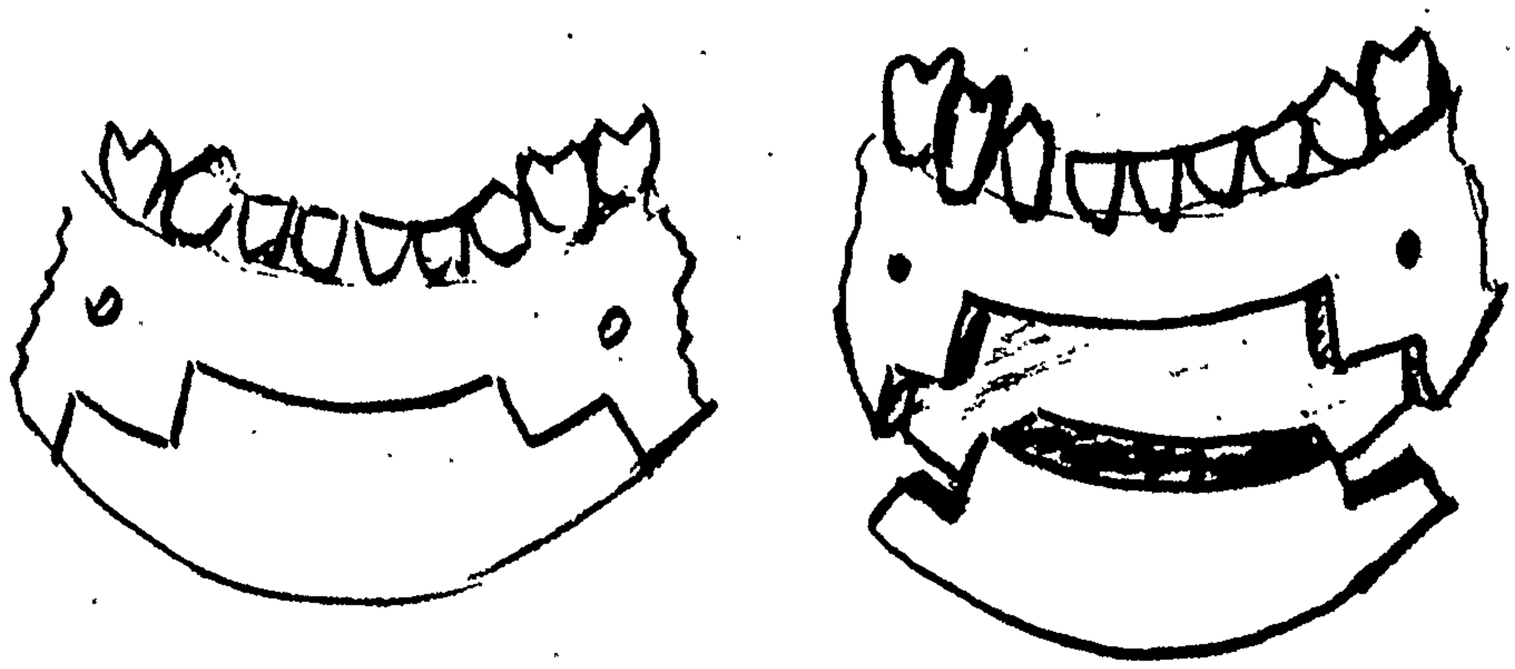
(a) sometimes the mental foramen was positioned too far anteriorly and inferiorly and therefore compromised the horizontal cut of the horizontal osteotomy.

(b) the thickness of the symphysis antero-posteriorly could sometimes limit the degree of movement of the symphysis fragment.

(c) when lengthening the facial height (microgenia) a graft or alloplastic graft is required.

(d) where segmental alveolar surgery is required in combination with chin advancement, chin retrusion or increase in facial height, there may not be sufficient bony height and thickness to allow the appropriate combination to be carried out.

It was because of these problems that the sagittal symphysotomy was devised. The procedure requires the removal of the



Super & Guernsey's Sagittal Symphysotomy.
After Super & Guernsey 1977.

Diagram 158

labial plate of the symphysis, including the lower border, with maximum width of lateral spread of the "wings" mindful of to avoid the mental nerve. See **diagram 158.** The anterior/inferior fragment can be lengthened vertically and still maintain adequate bone contact, or by trimming the fragment the chin can be intruded posteriorly or superiorly in cases of macrogenia either vertically, anteriorly or both.

If this procedure were to be used for the correction of microgenia with an anterior deficiency then a graft would be required and in view of the more complicated nature of the surgery compared to other procedures available, then this procedure would have limited application for the correction of anterior deficiency microgenia. There is however a definite place for the use of this procedure.

General Indications in Macrogenia Procedures.

Indications for procedures to correct chin deformities in general are not necessarily based on the type of deformity. That is because there are many procedures that will adapt to the deformity such as the Horizontal body osteotomy of Trauner and Obwegeser. Most of the procedures below are variations of the horizontal osteotomy of Trauner and Obwegeser.

A. Horizontal Body Osteotomy.

This procedure is best suited to those cases that show a prominent symphysis but otherwise show a normal occlusal plane, a Class I occlusion, and a normal vertical dimension of the face apart from an enlarged symphysis. The osteotomy will only intrude the symphysis posteriorly.

B. Sliding Oblique Horizontal Osteotomy.

The procedure is best suited for those cases that show a short ramus, an obtuse gonial angle and a steep, straight mandibular occlusal plane. In effect the symphysis is abnormal antero-posteriorly and can be enlarged vertically. The procedure can reduce the vertical dimension of the face where a "sandwich" of bone is removed at the same time.

C. Step Horizontal Osteotomy

The procedure is indicated where there is a normal or even acute gonial angle, a normal mandibular/occlusal plane and the vertical dimension is satisfactory. The chin itself is excessive in the antero-posterior dimension.

D. "Sandwich" Horizontal Osteotomy with Vertical Shift

For use where there is inadequate vertical dimension. The "sandwich" of bone can be added to boost the vertical dimension, where the symphysis is enlarged antero-posteriorly but deficient vertically. In the case of the abnormally long lower third of the face, a "sandwich" can be removed and the symphysis simultaneously intruded vertically and posteriorly.

E. Horizontal Osteotomy and Resection with Vertical Shift

Where the vertical dimension of the lower third of the face is excessive, and the deformity lies predominently in the symphysis region. In effect a "sandwich" of bone is removed to reduce the macrogenia.

F. Horizontal Osteotomy with Vertical and Horizontal Shift

This may be indicated in people who have an obtuse gonial angle. The chin shape is normal but has too much extension inferiorly and insufficient extension anteriorly.

G. Sagittal Symphysotomy in cases where there is an inferiorly and anteriorly placed mental foramen contra-indicating the use of the horizontal osteotomy, insufficient bone thickness again contra-indicating the use of the horizontal osteotomy.

*****

Summary.

In general Microgenia requires one or a combination of:

I. Augmentation: either Synthetic.

or Bone graft.

II. Horizontal Osteotomy: with a graft

without a graft.

Macrogenia requires one or a combination of:

I. Horizontal Osteotomy: without a graft.

with a graft.

II. Body Ostectomy:

III. Sagittal Symphysotomy:

IV. Body Shave:

Where there are nasal or occlusal deformities these should be seen to first as correction of these problems may require that the genioplasty procedure originally contemplated be changed, or may prove to be unnecessary. Correction of either or both the nose and the occlusion subsequent to genioplasty may require a further genioplasty to correct a consequent facial/symphyseal imbalance. (Rish 1964; Millard 1968; Hinds & Kent 1972).

oOo

MANDIBULAR ARCH DEFORMITIES

Segmental Subapical Procedures

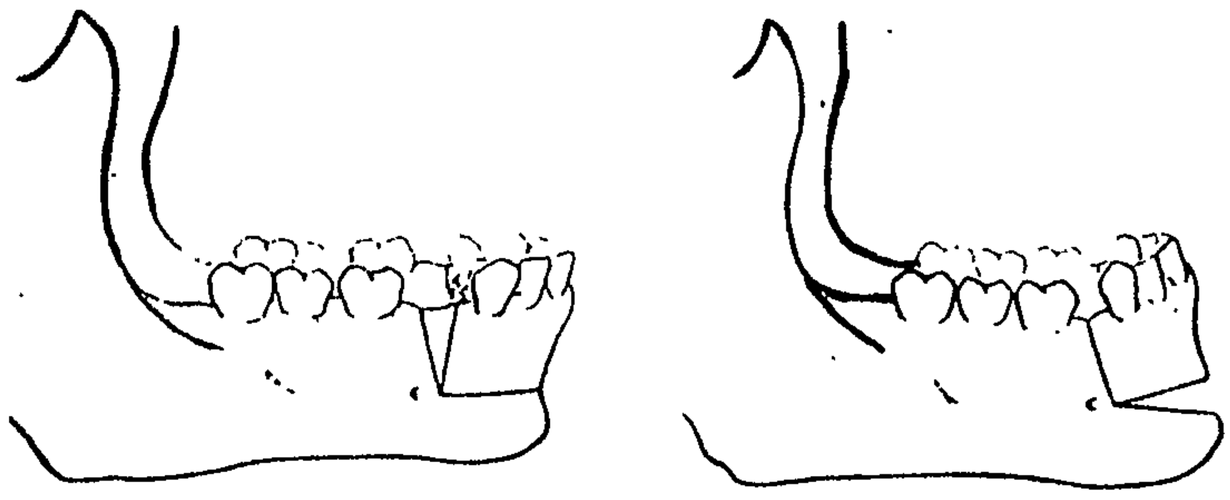
Introduction.

The segmental subapical procedures have become well reported due to their flexible nature. Although originally developed for the correction of open bite deformity, they have been expanded by Köle and others since into precise procedures capable of dealing with a variety of localised arch deformities as well as more extensive skeletal deformities.

Discussion.

Hullihen (Hullihen 1849) published the first subapical procedure for the correction of open bite deformity. The procedure created interest at the time but subsequent development favoured more complicated procedures that involved the whole of the body of the mandible. See **diagram 159.**

It was not until nearly 100 years later that Köle (Köle 1959a, 1959b, 1965) published his series on subapical osteotomies (or anterior mandibular alveolar osteotomies), attributing his original idea to Hofer (Hofer 1936, 1942), see **diagram 160,** but clearly the concept belongs to Hullihen (Hullihen 1848) with his subapical procedure for the correction of an anterior open bite deformity. Köle presented a series of of subapical osteotomies (or anterior mandibular alveolar osteotomies). See **diagram 161.** Köle's procedures were more refined than his predecessors. As already mentioned the procedures were adaptable so that the anterior apical fragment could be shifted in almost any



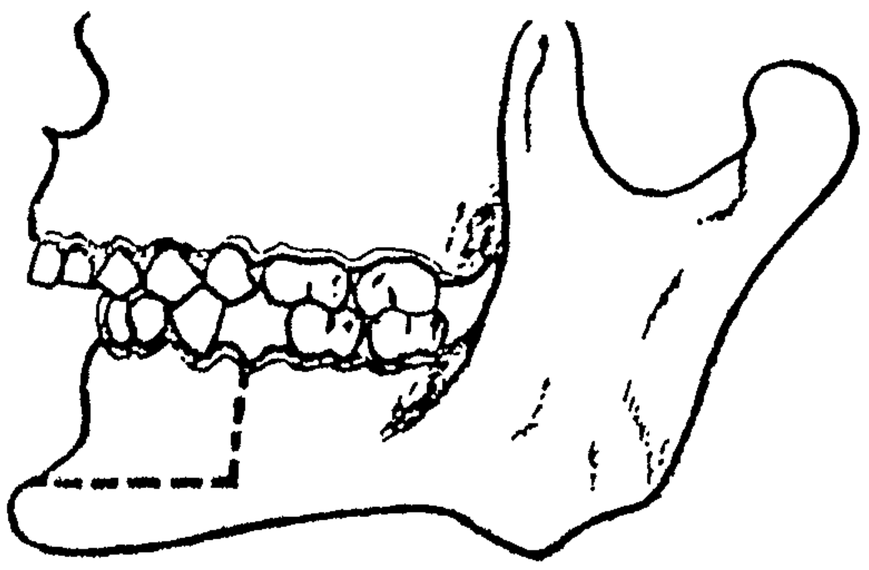
Correction of open bite according to Hullihen. V-shaped section two-thirds through mandible.

Hullihen's Subapical Osteotomy. 1848. From Thoma 1943.

Diagram 159

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 can be used for the correction of localised deformities such as diastemas, deep open bites and similar segmental deformities as well as anterior open bite deformity. The procedures could be combined with other procedures such as genioplasty, or even ramus or body procedures where the mandibular deformity is severe. However Köle did not use the subapical procedure for the correction of anterior open bite deformity. On the contrary, Köle recommended a full thickness body procedure, an inverted wedge procedure with the base of the wedge on the lower border. See **diagram 162.**

Köle (Köle 1959a) gave the name "corticotomy" to some of his segmental procedures. Those procedures that only required sectioning through the cortical bone just into cancellous bone after mucoperiosteal flaps were raised. The bony cuts were made on both the palatal/lingual and buccal/labial cortical plates either



Hofer's method of advancing the entire alveolar fragment in case of alveolomandibular retrusion.

From Kole 1959. After Hofer 1936.

Diagram 160

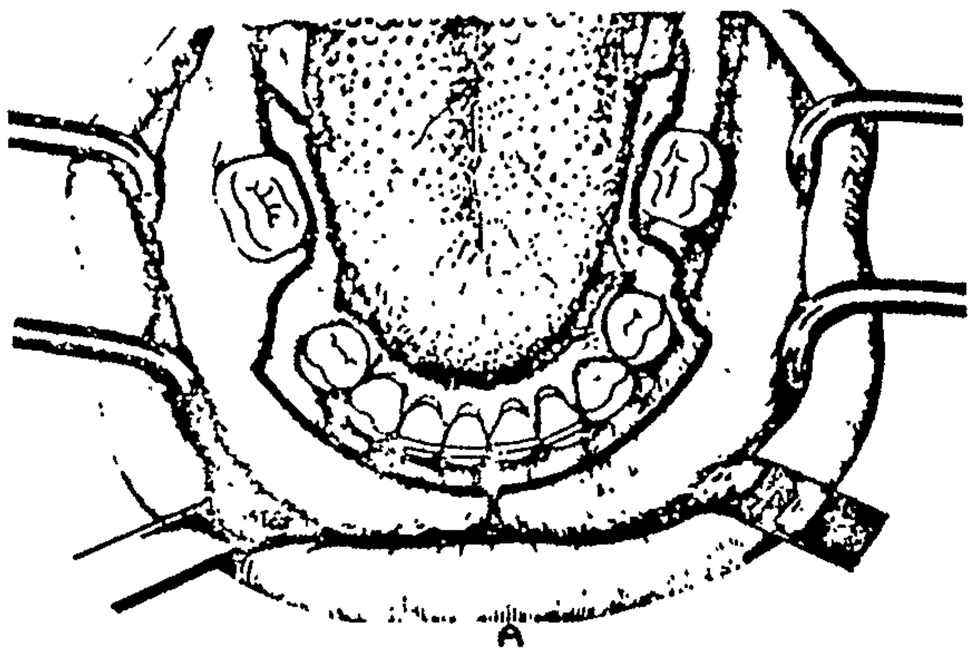
side of the tooth-bearing segment. The segment could contain one or more teeth. The relevant flaps were replaced and conventional orthodontic mechanics were undertaken.

It was Köle's objective to achieve the following:

1. Dento-osseous movement by orthodontic forces.
2. To produce rapid orthodontic movement.
3. To improve the stability of results. (Köle 1959a).

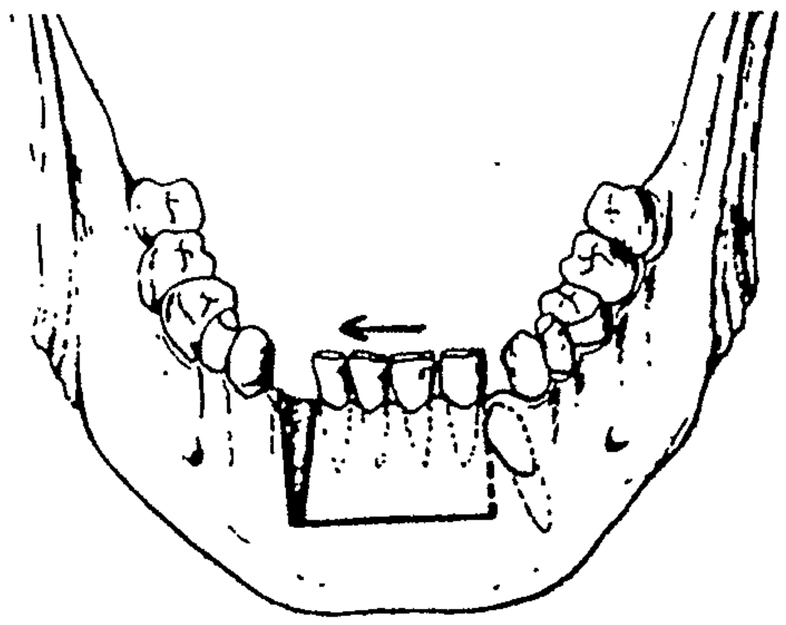
Köle reviewed his experiences with the subapical osteotomy technique (and other techniques) for the correction of prognathism. Where the prognathism was accompanied by open bite deformity then Köle recommended the use of the subapical procedure. There was substantially little change in the procedure as first reported. (Köle 1965).

Murphey and Walker (Murphey & Walker 1963) were the first Americans to report on the procedure of Köle/Hofer. The surgery performed was a simultaneous maxillary and mandibular Köle procedures for the correction of a Skeletal II facial deformity, by

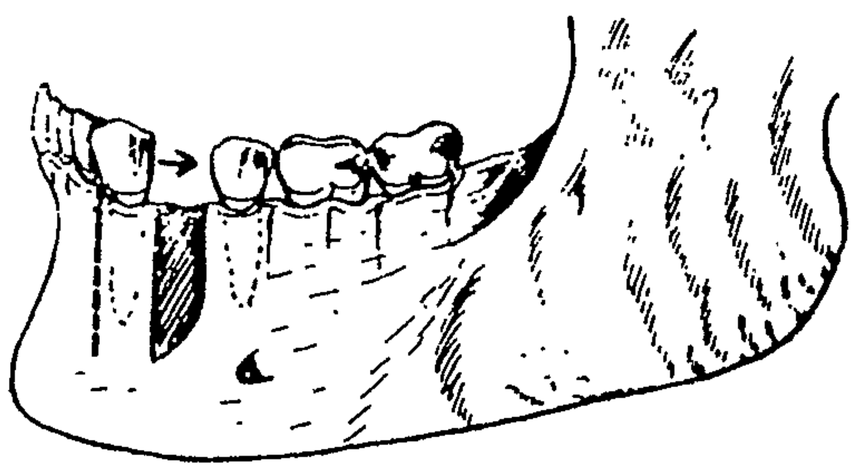


A – New mucosal incision (Kole).
B – Cross section showing osteotomy and circumferential wiring.

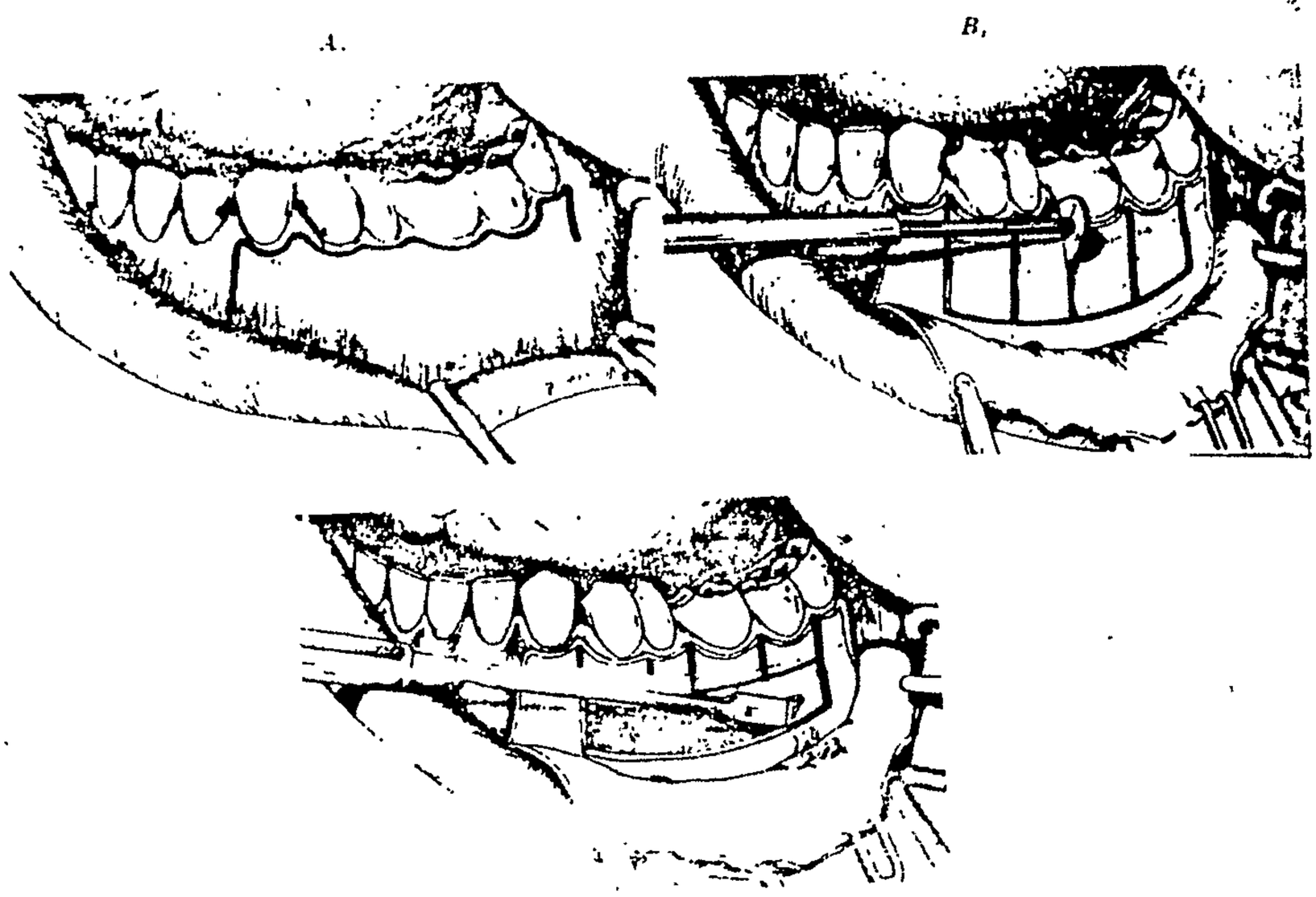
Kole's Subapical Osteotomy for Retrusion.
From Kole 1959.



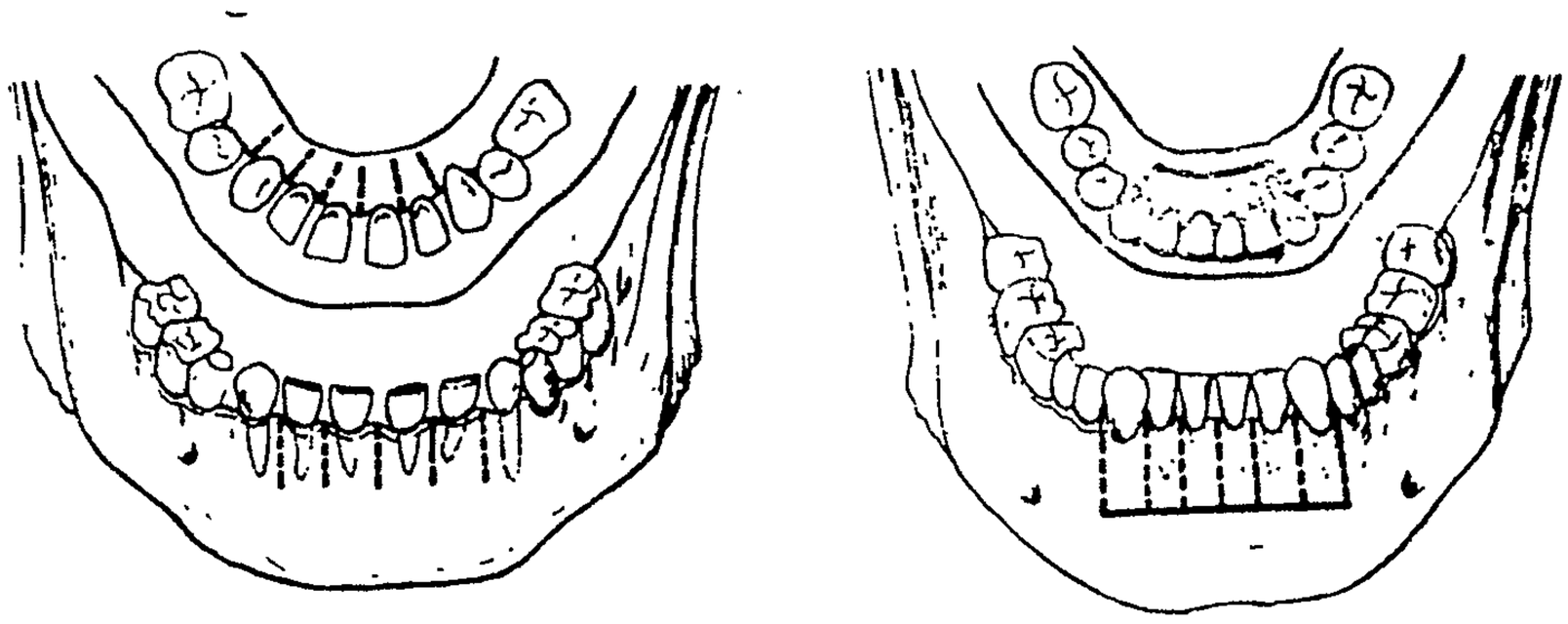
Kole's Subapical Osteotomy for Lateral Movement. From Kole 1959.



Corticotomy for One Displaced Tooth
(Anteriorly Placed Canine)



Corticotomy for Posterior Crossbite (Linguoversion).



Corticotomy for Anterior Spacing

Corticotomy for Anterior Crowding

A Range of Corticotomy Procedures for Single Tooth or Segmental Deformities. From Kole 1959.

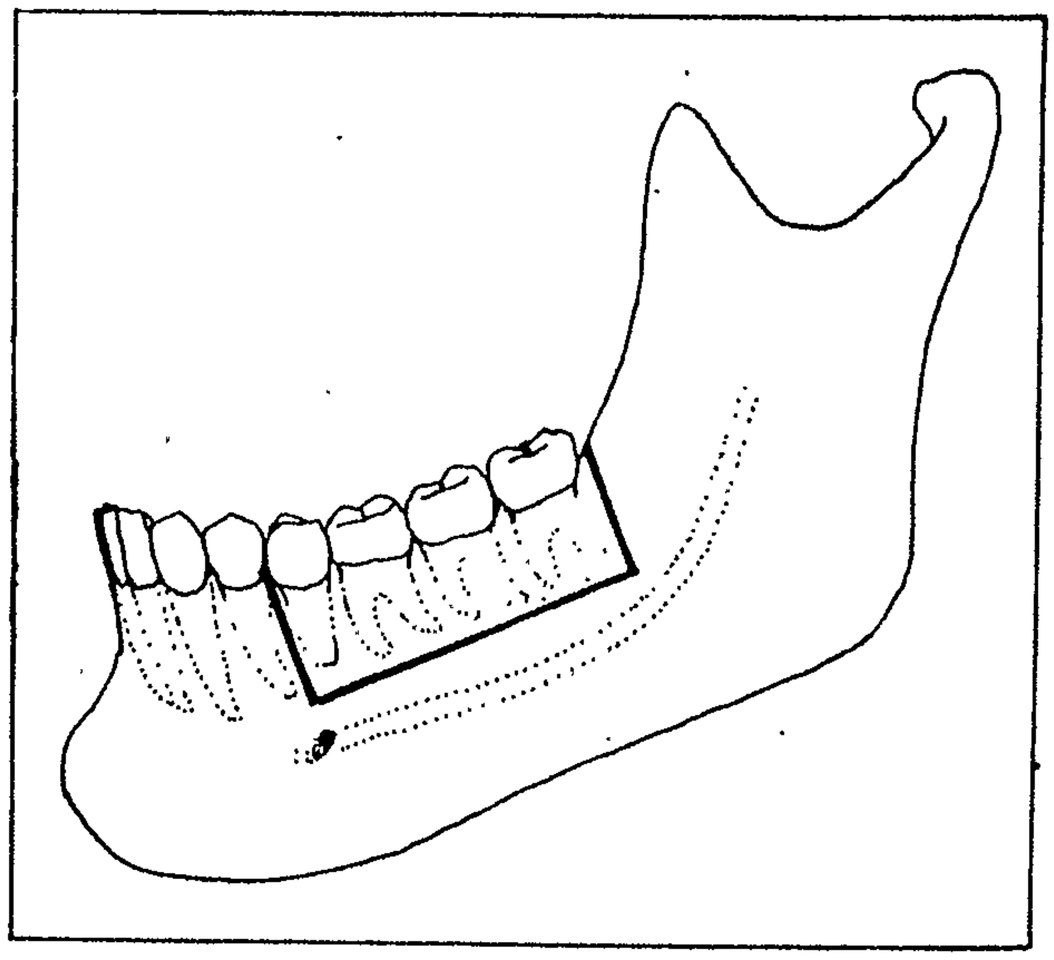
retruding the maxillary anterior segment and protruding the mandibular anterior segment.

There have been several reports since then, all trying to expand or improve the original series of procedures. (Clark 1968; Bell 1970; Pedersen 1973; Peterson 1973; Merrill & Pedersen 1976; and Burk, Provencher & McKean 1977). All attempted to correct small adult malocclusion deficiencies, without orthodontic procedures being undertaken.

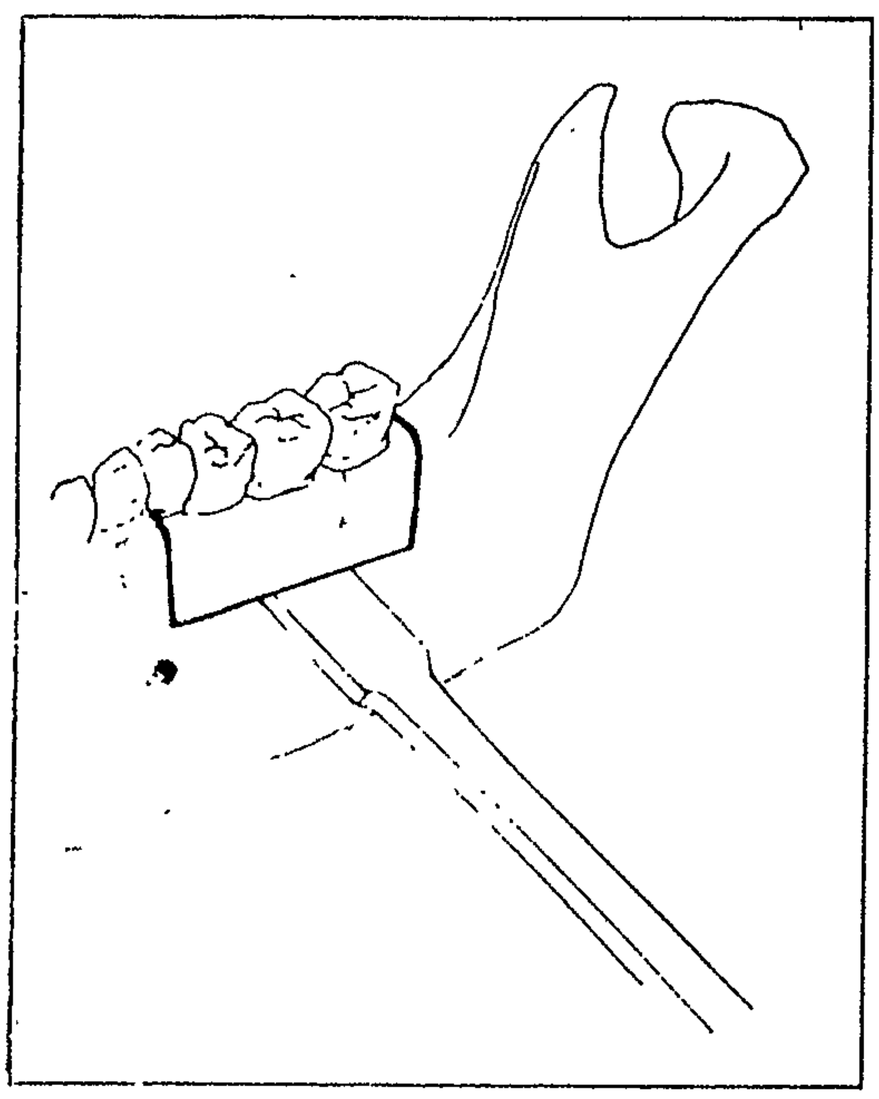
Bell and Dann (Bell & Dann 1973) used a split segment subapical osteotomy for the correction of overerupted mandibular anterior teeth. The procedure was performed for the correction of deep over-bite and excessive overjet, a severe Class II Div. I deformity. The deformity was corrected by means of anterior subapical surgery on both the mandibular and maxillary anterior teeth. The mandibular surgery was performed to intrude the mandibular teeth, which had overerupted, and to retrude the anterior teeth because they had slightly protruded.

Bell and Dann were most pleased with the success of their procedures regarding short-term stability. Average follow-up time was twenty five and a half months.

Provided that care is taken in the planning of these subapical procedures, good results can be expected. The incidence of non-vital teeth is low, there is minimal interdental bone loss and a lack of post-operative periodontal problems. (Bell 1969; Pepersack 1973). Lack of problems are attributed to careful treatment planning, and the need to remove teeth at the site of the



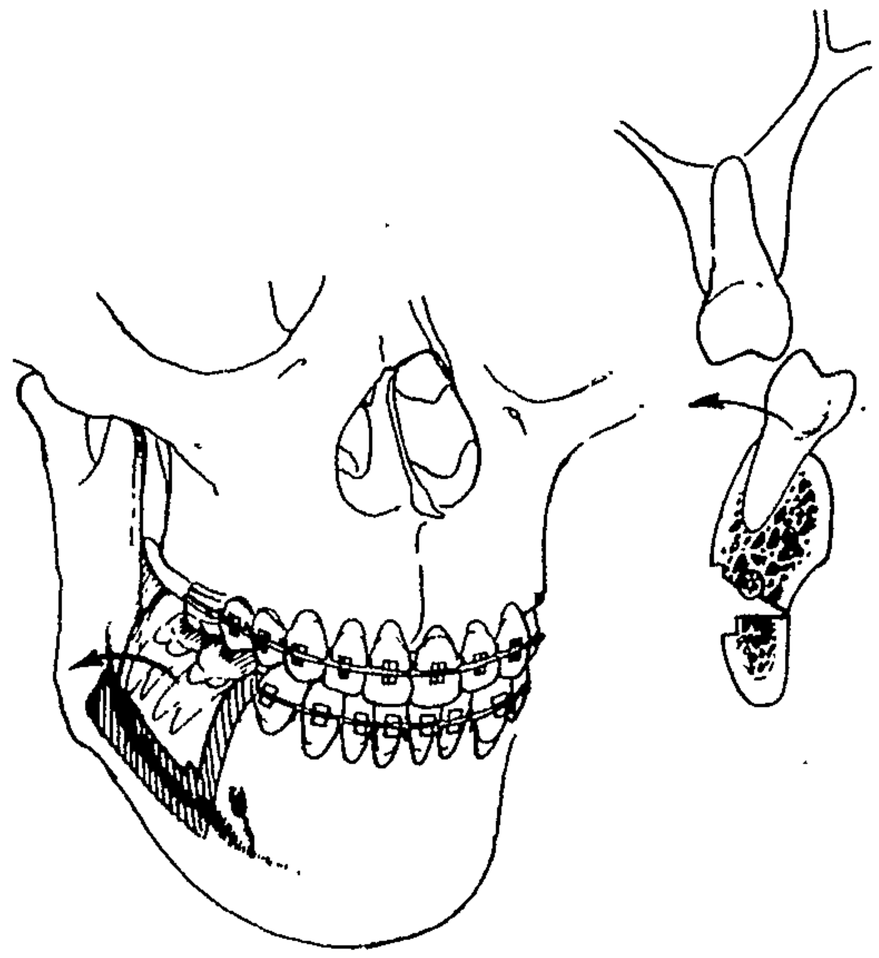
-Diagram of osteotomy indicating proximity of posterior teeth to inferior alveolar canal.



Thick splitting chisel is inserted into lateral horizontal osteotomy to mobilize dento osseous segment.

Peterson's Posterior Subapical Osteotomy. From Peterson 1978.

Diagram 163



POSTERIOR SUBAPICAL MANDIBULAR SURGERY

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

Diagram 164

osteotomy, even where an expansion procedure is being considered. Sometimes where the procedure is taken in stages, damage is even less. (Kohn 1972, Johnson & Hinds 1969, Hutchinson & MacGregor 1972; Astrand, Nord, Hellem & Persson 1977).

Peterson (Peterson 1978) reported the first use of the subapical osteotomy for the correction of posterior mandibular alveolar deformities. See **diagram 163.** Indications for the procedure were;

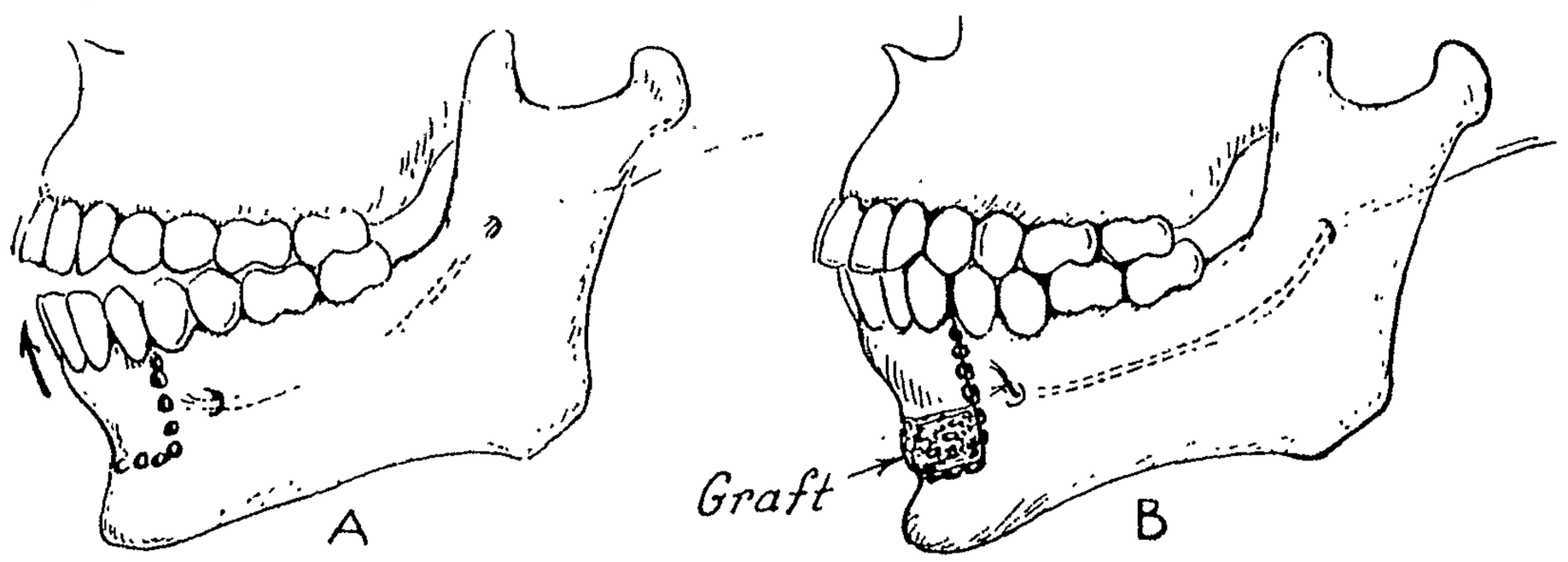
(a) Uprighting lingually or buccally placed tooth segments,

(b) Uprighting mesially tipped teeth,

(c) Depressing overerupted teeth,

(d) Closing interdental edentulous spaces,

(e) Combination treatment of any or all of the above.



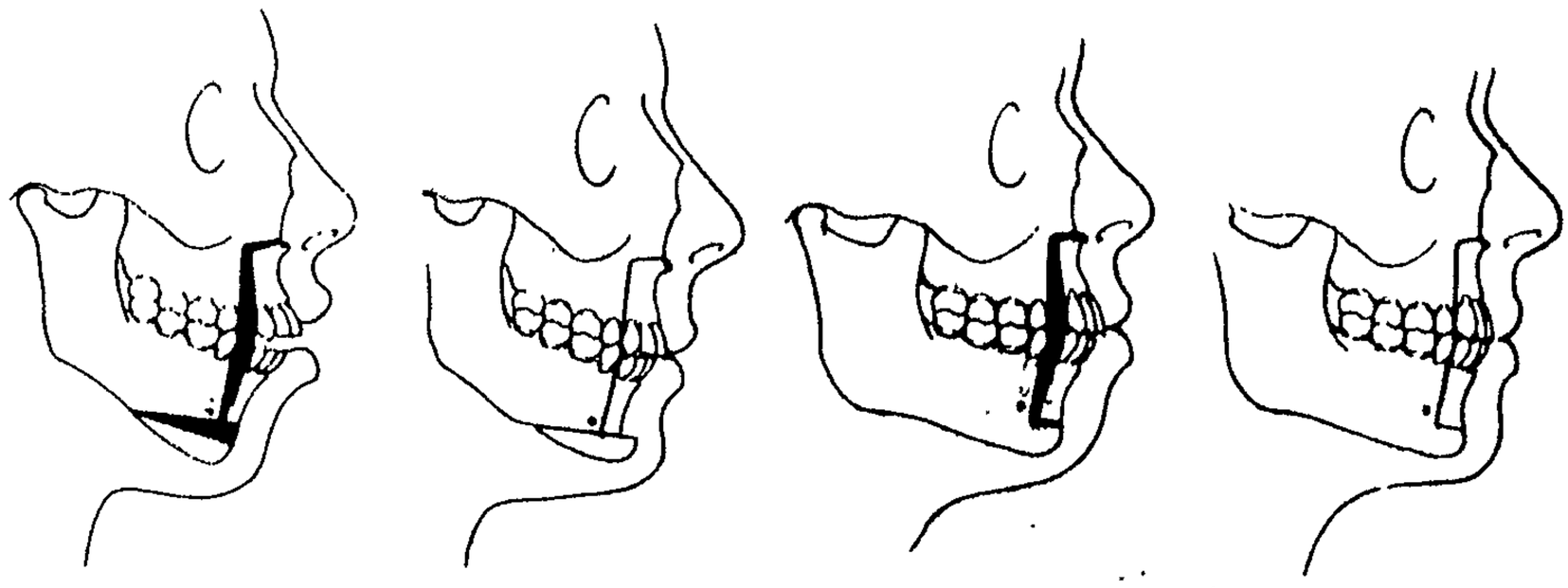
Schuchardt's method of correction of anterior open bite. *A*, The anterior dental segment is outlined with perforating burrs. *B*, The anterior segment is mobilized vertically, the open bite closed and a bone graft placed in the resulting bone defect.

Schuchardt's Anterior Subapical Osteotomy for the Correction of Anterior Open Bite, using Iliac Crest Bone. After Schuchardt 1961.

Diagram 165

There is the obvious complication of damage to the mandibular neurovascular bundle, but Peterson reported that in all cases full nerve function returned in three months or less. Epker and Wolford (Epker & Wolford 1980) demonstrated this procedure in their well illustrated book. See **diagram 164.**

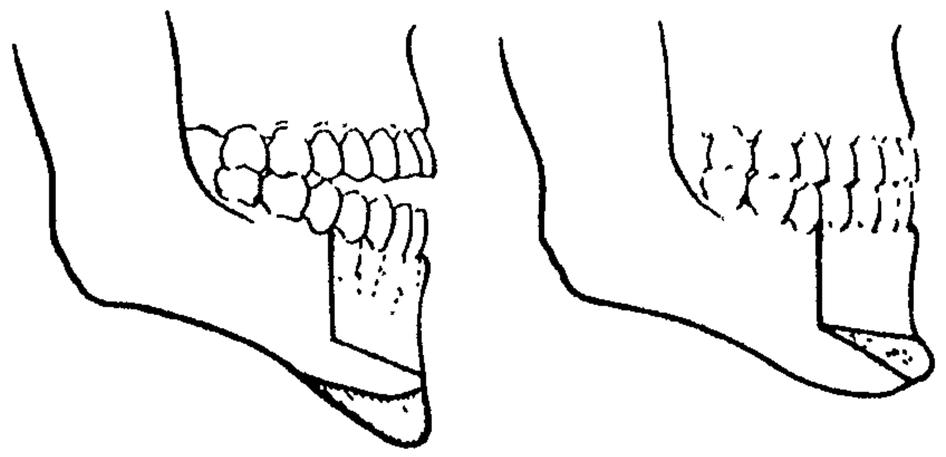
Subapical procedures have been used and recommended for non-skeletal open bite. Schuchardt (Schuchardt 1961) was one of the first to recommend the use of a graft, (an iliac crest graft), to fill in the bone gap when the anterior segment is raised. Schuchardt was probably the first to report this use of the anterior segmental subapical osteotomy. See **diagram 165.** Astrand, Nord, Hellem and Persson 1977 (Astrand, Nord, Hellem & Persson 1977) and Bell & Dann (Bell & Dann 1973), the latter report mentioned above, also



Bell & Dann's Multiple Anterior Subapical Osteotomies for the Correction of Anterior Open Bite Deformity. From Bell & Dann 1973.

Diagram 166

recommended the subapical procedure for the correction of anterior open bite deformity, along with the simultaneous correction of a maxillary anterior open bite and a deficient chin (a horizontal body osteotomy was used simultaneously); as well as for the correction of bimaxillary protrusion in conjunction with an anterior maxillary procedure. See **diagram 166.** The latter authors (Bell & Dann 1973) emphasised the versatility of the procedure for correcting mild to moderate deformities. Essentially the anterior height has to be normal or near normal with a lip line that will allow the anterior teeth to be raised. The gonial angle is normal as is the posterior facial height. The mandibular occlusal plane should also be normal. The procedure can be done with or without premolars being extracted at the osteotomy site. Hinds and Kent recommended that the premolars be extracted only where there is retrusion of the anterior segment required as well as correction of the open bite. (Hinds & Kent 1969). A wedge of bone can be used to support the elevated anterior fragment. This may be taken from the iliac crest or rib, or from the symphysis where an accompanying genioplasty is required to shorten the lower third of the face. (Reichenbach, Köle & Bruckl 1965).



-Procedure of Kole: inferior border is transferred when correcting open bite by alveolar osteotomy.

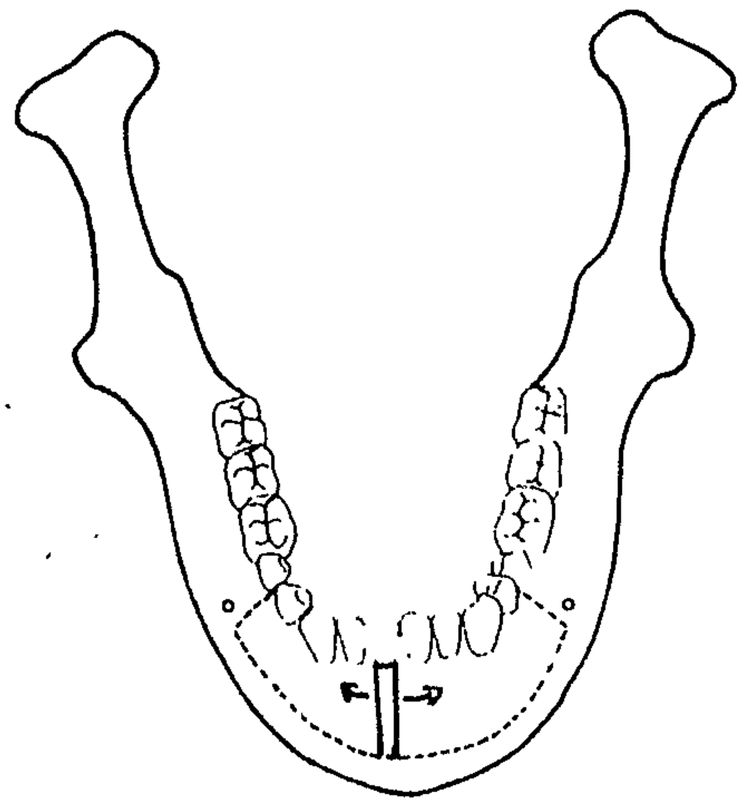
Reichenbach, Kole & Bruckl's Anterior Subapical Osteotomy for Correction of Anterior Open Bite, using the Symphysis as the Bone Graft. After Reichenbach, Kole & Bruckl 1965.

Diagram 167

See **diagram 167.** Köle (Köle 1959a,b,c) used orthodontic bands for fixation, while Hinds and Kent recommended the use of acrylic splints, and Taylor et al. recommended the use of cap splints for their subapical osteotomies for the correction of non-skeletal open bite (Taylor, Mills & Brenner 1967).

Taylor et al. (Taylor, Mills and Brenner 1967) and Barton (Barton 1973) recommended the use of the Köle procedures for the use and correction of anterior open bite deformity. They recommended that the fixation be applied through the use of cap splints.

Bell (Bell 1978) recommended the use of the anterior (mandibular) subapical osteotomy for obtaining an increased arch perimeter in a case of severe Class II div. II malocclusion with a mild retrognathia. The correction of the skeletal deformity



Bell & Dann's Anterior Subapical Osteotomy, with Midline Split, for Correction of Insufficient Arch Length. From Bell & Dann 1973.

Diagram 168

required a mild degree of body correction using the sagittal split procedure. As there was still a functional crowding deficiency, this was corrected by expanding the anterior dental segment using Köle's procedure. See **diagram 168.** Bell also recommended the Köle procedure for the correction of open bites but did not present any cases.

In Epker and Paulus's experience (Epker & Paulus 1978), they noted that the original series of corticotomies as described by Köle (Köle 1959a) were not satisfactory. In their view treatment time was decreased but only minimally and in some cases (ankylosed teeth) did not work at all.

Epker and Paulus expanded and described a series of single tooth osteotomies. This series of procedures was designed to improve on the original series of corticotomies as described by Köle

and to place them into a general order. The series they described were:

I. Single-stage (surgical) dento-osseous osteotomies

A. One-stage dento-osseous osteotomy with immediate manual repositioning of tooth bone segment

B. One-stage dento-osseous osteotomy with immediate orthodontic movement of tooth-bone segment

C. One-stage dento-osseous osteotomy with immediate manual repositioning followed by finishing orthodontic tooth movement

II. Two-stage (surgical) dento-osseous osteotomies

A. Two-stage dento-osseous osteotomies with immediate manual repositioning of tooth-bone segment

B. Two-stage dento-osseous osteotomies with immediate orthodontic movement of tooth-bone segments

C. Two-stage dento-osseous osteotomies with immediate manual repositioning followed by finishing orthodontic tooth movement

Specific indication for the procedures were:

For procedure I.A. an ankylosed tooth is a good indication.

For procedure I.B. single tooth crossbites not readily amenable to orthodontics is a good indication.

For procedure I.C. an ankylosed tooth with other orthodontic problems.

These procedures can be used on one, two or up to three teeth, individually for single tooth malocclusions.

Where the malocclusion is composed of multiple teeth, where tooth roots are very close together, where there are

multiple large diastemas to be closed, where there are multiple small segments to be moved very large distances, and rotational movement of small segments, then a two stage osteotomy is recommended.

For procedure II.A. a severely tapered Class II maxillary problem with a small diastema.

For procedure II.B. a severely splayed and protruded Class II maxillary problem.

For procedure II.C. a deep anterior cross-bite, and also a severe maxillary Class II malocclusion with a very large diastema.

The procedures mentioned above (II type) were 2 stage surgical procedures. In Epker's view where there is more than one tooth to be moved and a simple vertical incision is insufficient to provide the access to the line of section and a flap is required to be raised, then the surgery is best performed in two stages to ensure the viability of the tooth bearing segment(s) and the teeth themselves. Epker and Paulus preferred to operate on the palatal aspect first and delay the buccal procedure for four to five weeks. The delay was to ensure that there was sufficient revascularisation of the segment from the re-attached flap.

This is in contrast to the first type of procedure. (I type). A vertical incision with minimal retraction can be sufficient for access and segment viability when the buccal and palatal surgery is undertaken simultaneously. It is important that each tooth has its own series of incisions, and that a flap is not raised.

On average, a two year follow-up was undertaken and the results were satisfactory. (Epker & Paulus 1978).

Summary.

The subapical procedures are clearly very versatile in the treatment of localised deformities of the arch of a wide variety. Such deformities that range from both types of antero-posterior problems (retrusion and protrusion); to vertical problems such as open bite or deep bite deformities; to lateral problems such as crossbites; to localised single tooth adjustments.

There does not appear to be a major problem with vascular supply to the resited segments where due care is taken in dealing with the fragments. (Bell 1969b). Nor would the procedure appear to limited to the area or number of teeth involved in a segment, again if due care is taken during the surgery.

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MANDIBULAR ARCH DEFORMITIES

Total Arch Subapical Procedures

Introduction.

Total Subapical procedures while being an extension in quantity of the segmental subapical procedures, do present technical difficulties that have limited the reports. These difficulties will be discussed, but the principle difficulty and therefore the main difference of these procedures to the segmental procedures, is that while they are both subapical, the total alveolar procedures are often infra-canal, i.e. between the inferior border of the mandible and the mandibular neurovascular canal, whereas the segmental procedures are supra-canal, i.e. between the canal and the apices of the teeth.

Discussion.

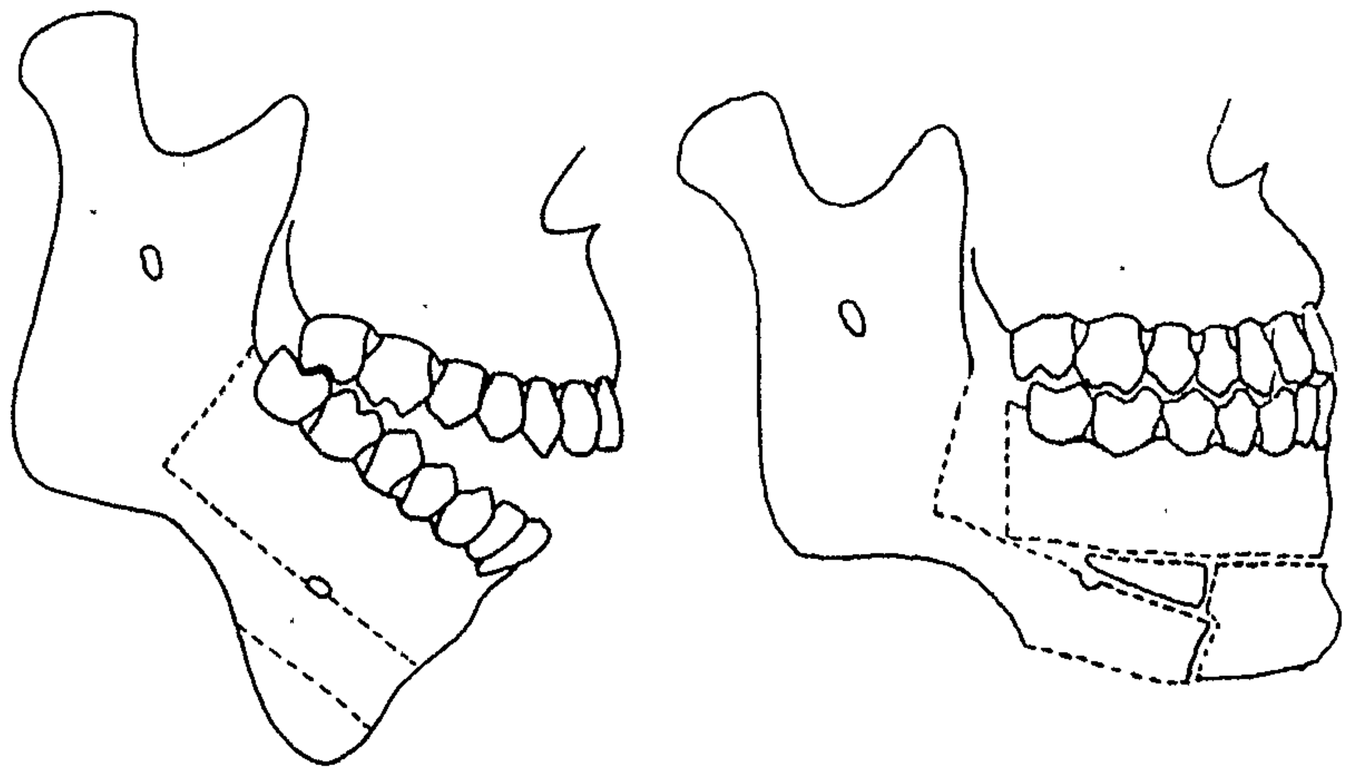
The first recorded attempts (successful) of total mandibular subapical procedure were by MacIntosh (MacIntosh 1974) for the correction of a series of open bite deformities. There were 7 cases in all presented in the report. The procedure was developed out of MacIntosh's early inability to achieve satisfactory results in correcting arch deformities with various ramus, body and alveolar techniques. MacIntosh acknowledged that the procedure was an extension of the procedures that were developed by Hofer (Hofer 1942) and Köle (Köle 1959a,b,c).

The osteotomy was approached intra-orally using a degloving procedure leaving the lingual tissues intact, except in those cases where the mandible was micrognathic. In that case the

Total mandibular alveolar osteotomy.

a) Position of the osteotomies at the base of the alveolus and across the symphysis.

b) The repositioned alveolar process supported by the transposed chin fragment and, as commonly used, the augmenting iliac graft.



.a .b

MacIntosh's Total Subapical Osteotomy for the Correction of Skeletal Open Bite Deformity. From Macintosh 1974.

Diagram 169

approach to the vertical retromolar section was extra-oral. The sections were as demonstrated in **diagram 169.** If the Mandibular neurovascular bundle is encountered in the posterior vertical incision, care is taken to free the bundle sufficiently to allow the alveolar fragment to be manipulated and reset, and at the same time protected using a ribbon retractor. Normally the horizontal section would expect to be superior to the bundle. However, especially in the posterior region of the body, the horizontal sections may have to be below the bundle. Iliac crest grafts and/or the resected symphyseal segment are used to support the mobilised alveolar segment in its predetermined new position. Fixation was a combination of intraosseous wiring and intermaxillary fixation with or without circumzygomatic and/or anterior nasal spine suspension.

Indications for the procedure were:

1. Shortened upper lip.
2. An even occlusal plane.
3. Unsatisfactory results predicted or obtained from other

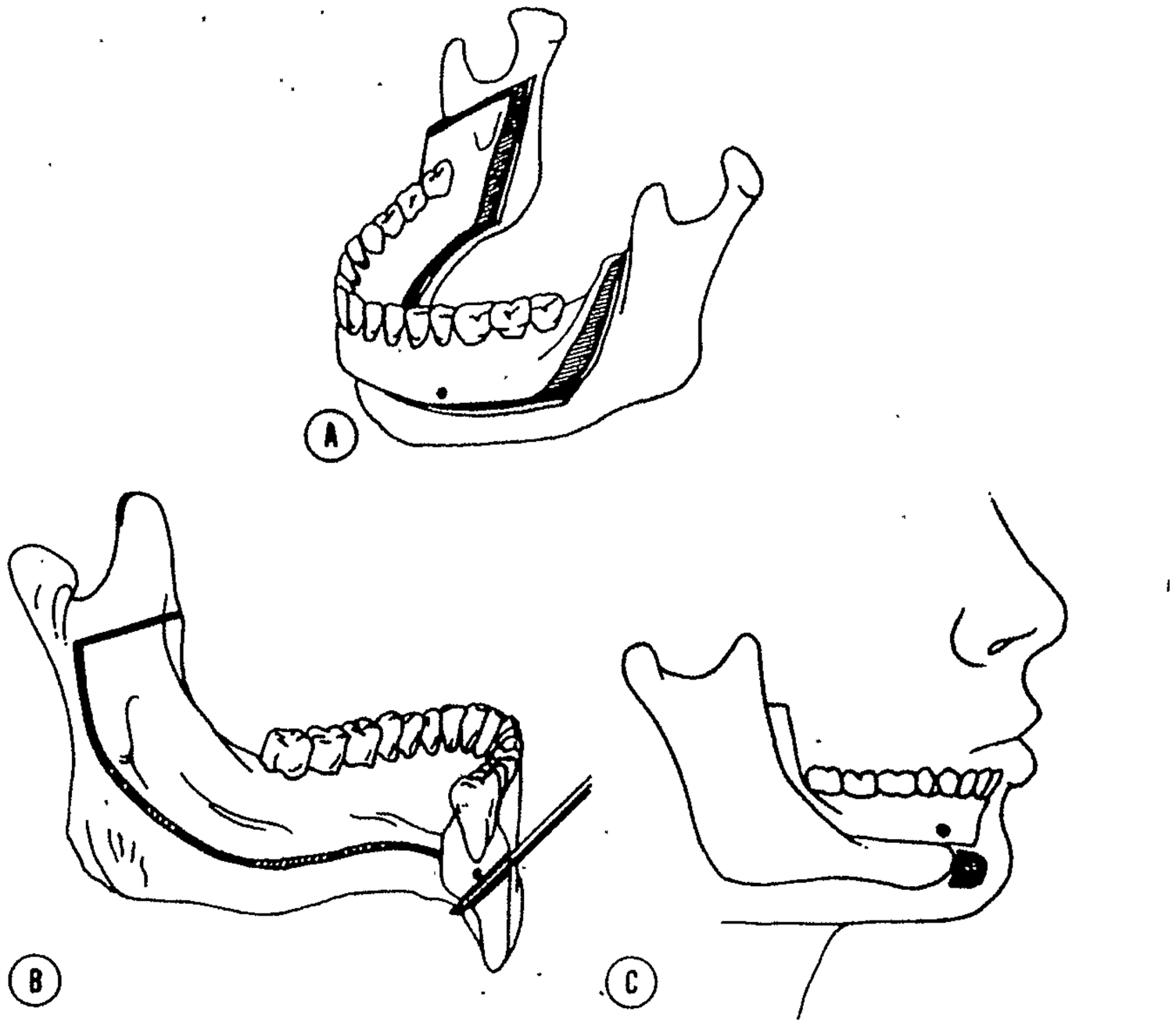
procedures.

4. Severe apertognathia.

MacIntosh admitted that trauma to the mandibular nerve was almost certain. Results were satisfactory and stable in the short term (Longest 27 months.).

Fitzpatrick (Fitzpatrick 1976) reported a total osteotomy of the alveolus of the mandible that was segmental in distinction to MacIntosh's one piece alveolus osteotomy. Section cuts between teeth were made with a very fine tapered fissure bur just into the cortex of the bone, and the section being completed with a fine osteotome. The separate segments were then aligned and locked into position by means of predetermined cast locking splints. Interosseous wiring was also employed. The indication for the surgery was where the base bone was in satisfactory position but the occlusion was not in satisfactory alignment, intra-arch in particular. The deformity was severe Class I crowding malocclusion.

In 1977 Dietz et al. described an unusual sagittal subapical procedure of the body of the mandible for the correction of severe overbite in a case of Class II Div. II malocclusion. The aim of the procedure was to avoid the mandibular nerve damage that was a substantial disadvantage to MacIntosh's procedure. The procedure was performed intra-orally via a degloving incision in the mandibular mucobuccal fold from the distal of the second molar on one side to the distal of the second molar on the other. With the flap raised, there was sufficient access to the ramus to allow a **medial** horizontal section to be made superior to the lingula through to the anterior border of the ramus. From the original starting point posterior and superior to the lingula, the section cut was then continued

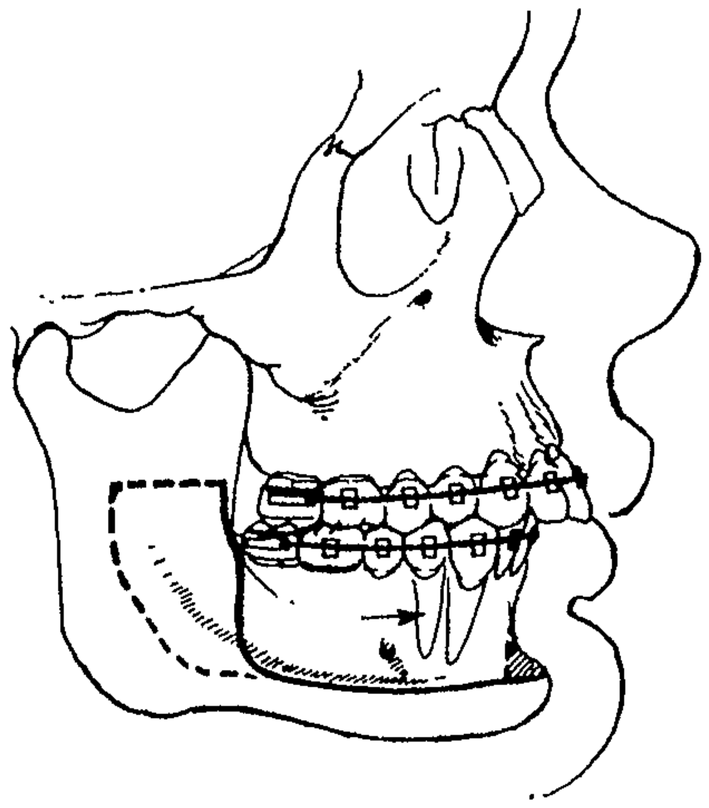


A, Diagram of the sagittal-segmental osteotomy undertaken in this patient. **B,** Diagram illustrating the angle at which the osseous section was performed. Advancement of the superior portion along the inclined plane increased lower face height. **C,** Diagram of a sagittal-segmental osteotomy with chin augmentation.

Dietz, Gianelly & Booth's Modification of the Total Subapical (Sagittal Split) Osteotomy for the Correction of Alveolar Retrusion and Mandibular Retrognathism. From Dietz, Gianelly & Booth 1977.

Diagram 170

inferiorly and then continued anteriorly when inferior to the mandibular canal. The inferior incision was continued subapically around the lingual surface of the mandible to meet with its opposite section cut on the lingual/medial surface of the opposite side. The **lateral** cut commenced where the horizontal medial cut began, on the anterior border of the ramus, and continued down the external oblique ridge until subapical and then proceeded horizontally around the buccal aspect of the mandible to meet up with the same cut on the opposite side. When the fragments were freed then the alveolar portion of the mandible with sufficient of the ramus to contain the



TOTAL SUBAPICAL MANDIBULAR SURGERY

The Sagittal Modification.
From Epker & Wolford 1980.

Diagram 171

intact neurovascular bundle, was reset anteriorly to give a normal occlusion with a corrected overbite. The body of the mandible, essentially normal in position, was left in its original position. Chin augmentation was also undertaken in one case and is also illustrated. See **diagram 170.** (Dietz, Gianelly & Booth 1977).

A further, similar procedure was reported by Murray (Murray 1980) which was successful. As a further indication for the procedure, along with deep bite, Murray was of the opinion that where the chin point is normal or even slightly protruded, and the dentition is in Class II malocclusion with deep overbite, the sagittal subapical split body procedure is indicated. The procedure was reported as very successful over 2 years after surgical treatment. Where Dietz et al reported 7 hours for their procedure, Murray noted that their procedure time was 3½ hours.

Epker and Wolford (Epker & Wolford 1980) also

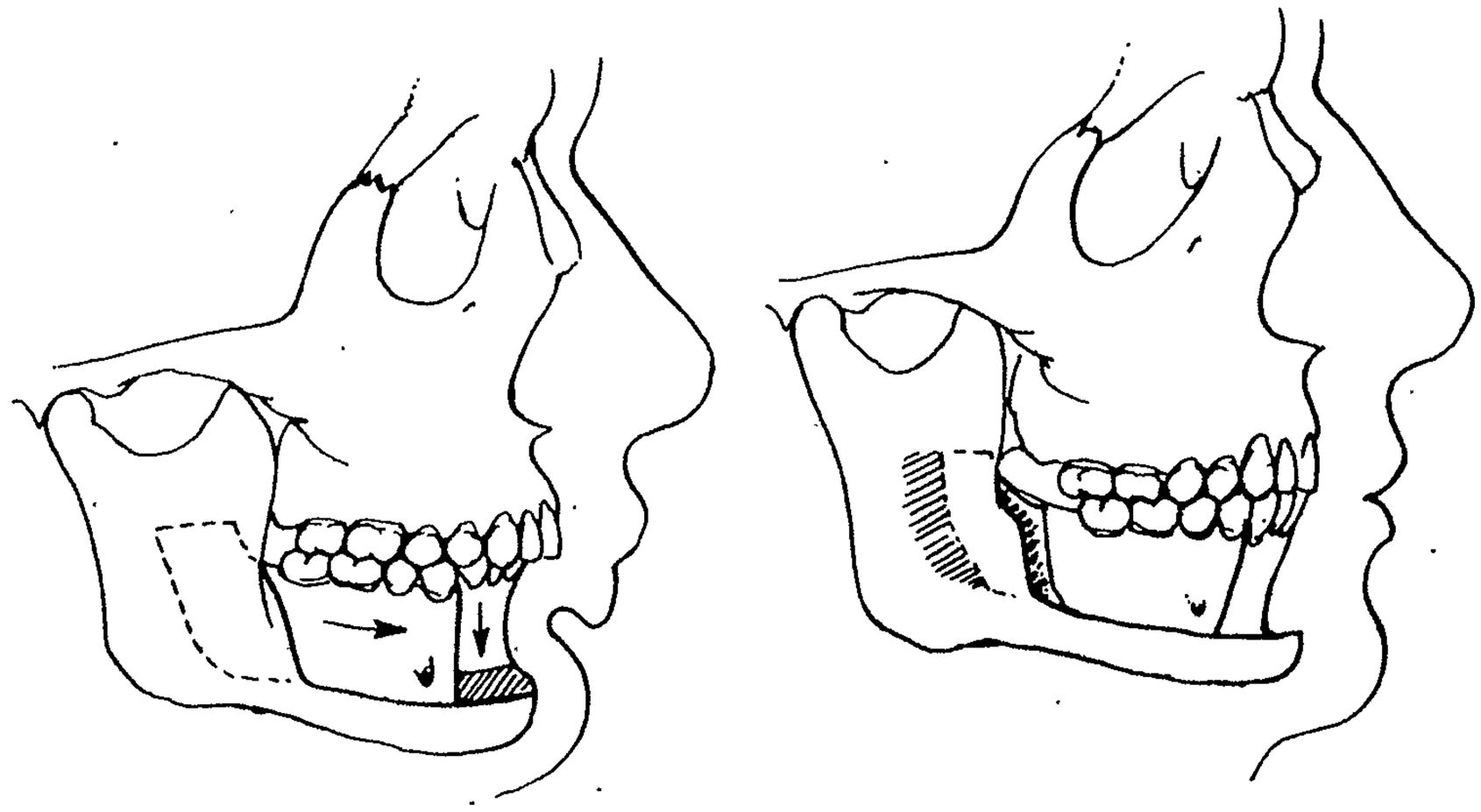
reported a sagittal total subapical osteotomy essentially the same as reported by Dietz et al, emphasising the need not to completely deglove the mandible, but to leave attachments to the inferior lateral and symphysis borders. See **diagram 171.** The horizontal section is also below the level of the mandibular neurovascular canal, a feature which is common to most of the total osteotomies and in distinction to the segmental alveolar osteotomies which are subapical but supra-canal. The one main advantage of the sagittal variation was that advancement of the fragment was far less likely to damage the nerve by stretching, than with the standard procedure. Hence most of the indications for the surgery are for the correction of a Class II occlusion.

Epker & Wolford gave the following indications for the sagittal total alveolar osteotomy.

1. Class II malocclusion with a low mandibular plane angle and a normal, although apparently prominent, chin point.
2. Class II malocclusion with an excessive curve of Spee.
3. Class II malocclusion with decreased vertical dimension of the lower third of the face.
4. Open Bite deformity where the deformity is solely in the mandible and the maxilla is normal. (Epker & Wolford 1980).

For the correction of the deformity noted in point 2. above, Epker and Wolford suggested the modification shown in **diagram 172.**

For the correction of the deformity noted in point 3. above, the procedure modification shown in **diagram 173** was recommended. (Epker & Wolford 1980).

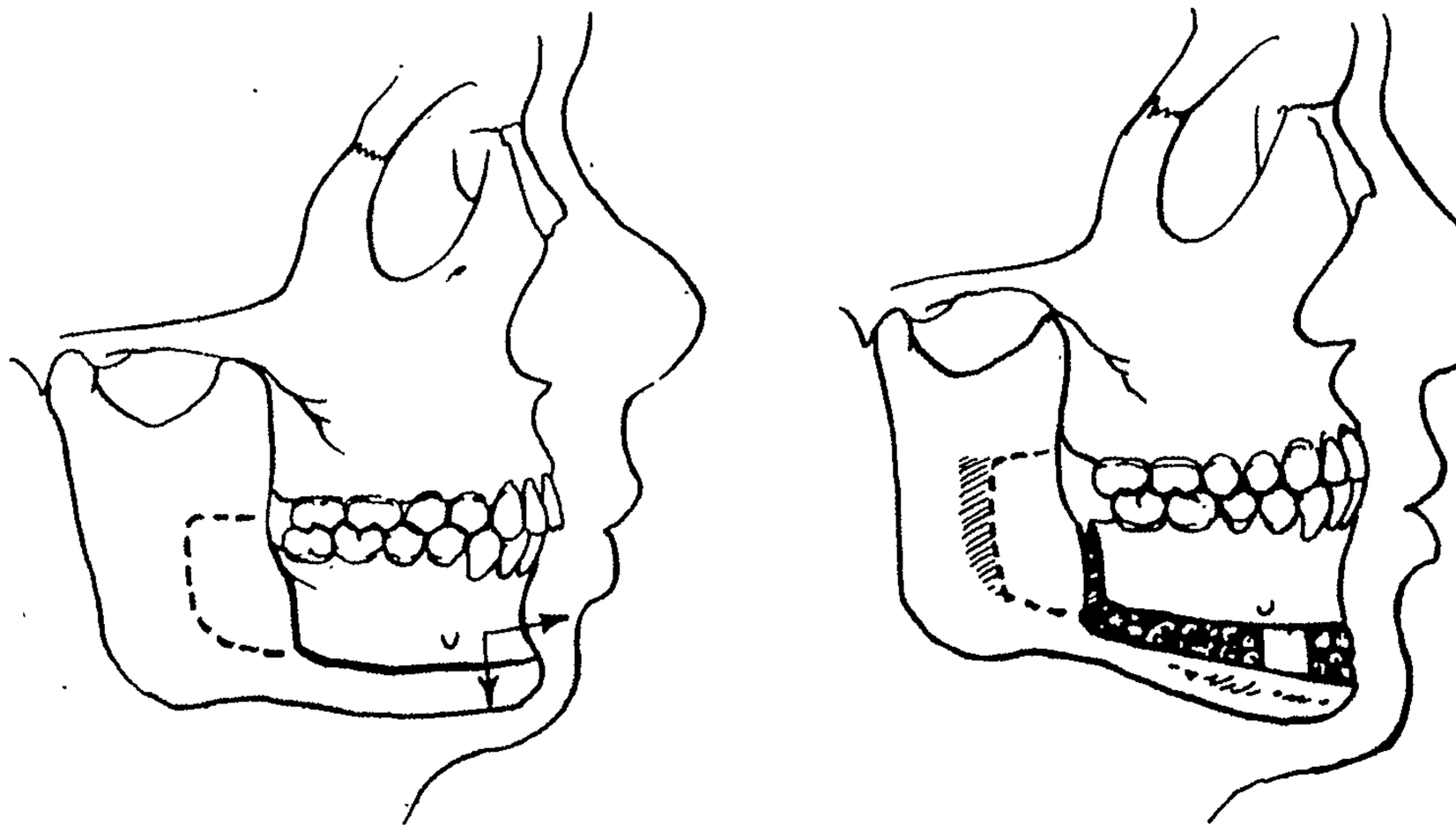


Epker & Wolford's Modification of the Sagittal Total Subapical Osteotomy for the Correction of Excessive Curve of Spee. From Epker & Wolford 1980.

Diagram 172

Both procedures would involve a greater risk to the mandibular neurovascular bundle, especially the variation for the correction of the deformity noted in point 2. Consideration would have to be given to this when selecting the procedure for the correction of Class II malocclusion with either an excessive curve of Spee or a decreased vertical dimension.

Piecuch and Tideman (Piecuch & Tideman 1981) also reported the use of a total mandibular alveolar osteotomy that was used for the correction of deep bite deformity with total mandibular linguoversion. The section cut commenced in the retromolar region and not in the ramus as Dietz et al described but more in the manner of MacIntosh's procedure. See **diagram 174.** The approach was not that used by Dietz et al. The incision is commenced in the gingival sulcus and carried forward until anterior to the mental foramen.



Epker & Wolford's Modification of the Sagittal Total Subapical Osteotomy for the Correction of Deficient Lower Third of the Face Deformity.
From Epker & Wolford 1980.

Diagram 173

The incision is then taken deeper into the labial sulcus to join up with the same incision from the opposite side. The periosteum is reflected to the inferior border. The section cut is made at a subapical level (4 mm. subapical was recommended) first with a round but and then completed with a Lindemann bur at slow speed to detect when the bur completes the lingual cortical sectioning. Thus no lingual periosteum is raised and blood supply to the fragments is ensured. Patently care must be taken on completing the lingual cortical sectioning with a bur. Piecuch and Tideman recommended that any remaining lingual attachments be detached with a small osteotome. A midline section cut was placed to allow each lateral segment to be tilted laterally, as well as the whole of the alveolus taken forward. Stabilisation was by direct osseous wiring and bone grafts were not thought necessary except as chips to fill any

Top, lateral view of rotation of alveolar process. Middle, anterior view of rotation of alveolar processes. Bottom, final position of alveolar segments.

Piecuch & Tideman's Total Subapical Osteotomy for the Correction of Deep Bite Deformity.
From Piecuch & Tideman 1981.

Diagram 174

defects and thus to speed healing. Intermaxillary fixation was not considered absolutely necessary but recommended. Piécuch and Tideman reported two cases.

Summary.

This procedure would be of benefit where satisfactory results were not forthcoming from other procedures. The procedure's main difficulty would be in dealing with the Mandibular nerve as damage at one or more sites must be inevitable. The surgery would not be contra-indicated in those cases where there was insufficient space between the apices of the teeth and the Mandibular neurovascular bundle as it is with segmental procedures. There would be few cases of deformed mandibular arches where there would be unsatisfactory access throughout the entire arch either above or below the important anatomical structures.

The surgery presents difficulties with splinting the segments, especially where there is compensatory growth in the maxilla and a satisfactory occlusion difficult to find without at least prior orthodontic alignment or similar surgery on the maxilla.

The sagittal procedure reported by Dietz et al would appear to avoid some of the neurovascular problems of MacIntosh's procedure. Indications for both variations of the total subapical procedure would appear to be limited. There have been no long term studies on total arch subapical procedures at this stage.

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CONCLUSIONS AND SUMMARY

The most important factor in the development of mandibular reconstructive procedures as it was for most reconstructive procedures, was the use of General Anaesthesia to allow the development and use of prolonged and technically difficult procedures. Prior to the use of General Anaesthetics, with the exception of Hullihen's procedure, no osteotomy procedures for the repair of a mandibular defect or deformity were reported. Although there were and occasionally still are reports of procedures being performed under Local Anaesthesia, all procedures have been performed and developed subsequent to the introduction of General Anaesthesia.

The initial procedures were not simple and crude as might be expected but very similar to the procedures that are used today, taking as examples the procedures of Hullihen, Blair, Babcock and von Eiselsberg. It was the difficulty of these procedures that led some surgeons to try simpler procedures mostly with poorer results. Many were discarded. It is of note that a full circle can be seen where procedures that were originally used, discarded, and then rediscovered were not substantially different than when first used. The original procedure being almost forgotten. Examples are Köle's procedure compared to Hullihen's procedure; Trauner & Obwegeser's retrocondylar procedure compared to Babcock's procedure of the same name. Both sets of procedure showed a similar development history. The original procedure was reported once and thereafter no longer used or reported, and almost forgotten, and then was reported many years later by different authors who were not entirely aware of the original procedure and differed from the original procedure only in minor ways. Both procedures showed

different subsequent histories with the Hullihen procedure becoming popular and being commonly reported with the Babcock procedure not as popular with surgeons and only rarely reported.

For such a relatively small bone as the mandible, there has developed a large number of various osteotomies to achieve disparate results. Some osteotomies such as Trauner & Obwegeser's sagittal split osteotomy of the ramus and Sada's sagittal split osteotomy of the body would not readily come to mind as solutions to a deformity problem. Other osteotomies have come as extensions of the original procedure in an effort to improve the original osteotomy such as the step body osteotomy is an improvement of the vertical body osteotomy. Still others have been developed to suit a small but specific need such as the sagittal symphysotomy of Sowray & Haskell's. Most are procedure that have been developed for a specific deformity and have ended up being adaptable and flexible for a second deformity or even multiple deformities.

Where there has been a requirement for extra tissue to make up inadequacies where extension procedures have been undertaken or simply to fill-in defects, there have been a number alternatives put forward to substitute for missing tissue. None have been entirely satisfactory. Despite the disadvantages of autografts in particular the need to perform a second operation, there have been no satisfactory long term substitutes for autografts be they hard or soft tissues (bone, cartilage, dermis, muscle, fat). Despite much research on the use of alloplastic materials, there does not appear to be a completely satisfactory material that can replace the autograft or even the homograft. Proplast for example has looked the most promising during the early stages but there does not appear

to be many long term reports. This has applied to all alloplastic materials.

Most reported refinements to procedures were usually related to the handling and treating of the soft tissues rather than the bony cuts themselves. There were after all a limited number of bony sections that could be done. The effect of the muscles and muscle groups associated with the mandible were noted and reported, and ways to overcome difficulties such as relapse and instability of the fracture were discussed. Post-operative problems of relapse have always been of importance and many techniques have been discarded almost entirely because of this post-operative problem. A good example being Winter's operation for the correction of apertognathia where the post-operative relapse was sometimes worse than the original apertognathia. A further example of soft tissue (muscle groups) effects was post-operative instability of fracture fragments of the ramus that led to the discarding of Babcock's Horizontal osteotomy of the ramus for the correction of prognathism.

Treatment of the neurovascular bundles was initially not considered and the osteotomy cuts paid no attention to the mandibular nerve for example. It was nearly thirty years after the first full thickness osteotomy cut was reported that a refinement was reported in an attempt to avoid sectioning the Mandibular nerve and preserving the function of the nerve. Thirty years later again there were still surgeons who disputed the need to protect the neurovascular bundle reporting that the difference in return to function between severed and not severed nerves was nearly the same.

Various surgical approaches to the same or similar

bony procedure have been reported, operations on the ramus probably having the greatest number of incision approach variations due to the many important structures and organs associated with this area of the mandible both medially and laterally. Hence there have been medial and lateral extra-oral approaches and oral medial and lateral approaches. There are not many reported variations on the number of oral approaches to the mandible, but there have been a considerable number of extra-oral (both blind and direct vision) approaches reported. Where early surgeons such as Hullihen and even later surgeons such as Hovell noted a greater number of infection problems with extra-oral approaches compared to intra-oral approaches, this became less of a problem with the advent of antibiotics which radically changed surgery and allowed access to surgical areas that were previously not thought possible, and allowed new procedures as well as new approaches.

As the problems appeared difficult or impossible to solve, either new incision approaches were suggested, or, more usually, entirely new procedures were reported. Some procedures succeeded such as Caldwell & Letterman's vertical subsigmoid osteotomy; others fell into disuse such as the subcondylar osteotomy of Kostecka.

The multiplicity of procedures as much reflects the personal preferences and training of individual surgeons. There has been a trend for countries or localities to report on similar types of procedures. For example, American surgeons have shown a marked preference for the vertical ramus procedures, whereas the European surgeons have shown a preference for both body procedures and sagittal ramus procedures. This is by no means a hard rule and there

are many exceptions on both sides of the Atlantic.

There has also been a tendency to simplify individual procedures both with a view to safety in the procedure and to lessen the surgical time, the latter being advantageous but not paramount. This would appear to be a general trend with all procedures. A good example being the sagittal split which was modified firstly to make the procedure more effective but at the same time more complicated, and then later reports showing a return to simpler variations.

In the first half of the century when surgeons were still examining individual procedures, they tended to perform single procedures. If the severity of the deformity required further correction then this was done at a later stage as a separate operation. Most of the reported procedures were based on the mandible. In the second half of the century, in the 1960's, there has been a tendency to combine osteotomies on the mandible to perform multiple operations, achieving results that would not be possible with any one procedure. An implicit reminder that there is no one ideal procedure.

In the 1970's more maxillary procedures were reported for the correction of deformities, firstly in single-procedure operations, and then staged-operations (one or two procedures at a time), and then multiple procedure operations, (the total deformity corrected at one operation). In the 1980's a trend for combined maxillary and mandibular procedures being performed simultaneously rather than staged has been seen. This has resulted in an increased complexity of the operation as a whole, with a very

much more important requirement for planning the operation prior to surgery, and with much more predetermined and precise bony cuts.

If there is any particularly important conclusion to be drawn it is that there is no one procedure that is the ideal procedure to correct any one deformity or group of deformities. The "favourite surgical procedure" concept should be discouraged. Where surgeons have experience in many types of procedures then a better selection of the procedure(s) for the case will be made. Mandibular bony surgery will never be a simple, easy, problem free, complication free procedure. Hence research and development must continue and new procedures or variations of old procedures will continue to be reported as solving one complication or avoiding complications, no doubt to create still other complications.

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APPENDIX ONE.

Diagrams

Prognathism (Condyle Procedures).

Diagram 1 — Kostecka's Sub-condylotomy Osteotomy. 1931.

Diagram 2 — Gonzallez-Ulloa's Pre-auricular Approach. 1951.

Diagram 3 — Gonzalez-Ulloa's Subcondylar Osteotomy. 1951.

Diagram 4 — Smith & Johnson's Subcondylar Osteotomy. Bony cuts and final position. 1944.

Diagram 5 — Smith & Johnson's Original Approach. 1944.

Diagram 6 — Smith & Robinson's Modified Approach. 1955.

Diagram 7 — Pettit & Walrath's Flail Joint Osteotomy. 1947.

Prognathism (Ramus Procedures).

Diagram 8 — Babcock's Horizontal Ramus Osteotomy. 1909.

Diagram 9 — Babcock's Pre-auricular Approach. 1909

Diagram 10 — Babcock's Variations on Ramus Osteotomies. 1909

Diagram 11 — Babcock's Forerunner of Kostecka's Subcondylar Osteotomy. 1928.

Diagram 12 — Babcock's Forerunner of Pankow's Angle Osteotomy. 1958.

Diagram 13 — Babcock's Forerunner of Caldwell & Letterman's Ramus Osteotomy. 1954.

Diagram 14 — Hensel's Pre-auricular Approach. 1937.

Diagram 15 — Schmidt & Wymer's Pre-auricular Approach. 1929.

Diagram 16 — Kostecka's Oblique Ramus Osteotomy. 1928.

Diagram 17 — Dingman's Variations of the Oblique Ramus Osteotomies. 1944.

Diagram 18 — Skaloud's Horizontal Ramus Osteotomy. 1951.

Diagram 19 — Schuchardt's Angled Ramus Osteotomy. 1942.

Prognathism (Body Procedures).

Retrognathism (Condyle Procedures).

Diagram 61 Trauner & Obwegeser's Herbst Hinge Splint.

Retrognathism (Ramus Procedures).

Diagram 62 Blair's Horizontal Ramus Osteotomy. 1905.

Diagram 63 Dingman's variations on the Oblique Horizontal Osteotomy of the Ramus. 1944.

Diagram 64 Blair's Genioplasty following Ramus Osteotomy. 1921.

Diagram 65 Limberg's Subcondylar Osteotomy. 1925.

Diagram 66 Kostecka's Subcondylar Osteotomy. 1931.

Diagram 67 Wassmund's "S" Ramus Osteotomy. 1927.

Diagram 68 Immenkamp's "S" Ramus Osteotomy and Graft. 1957.

Diagram 69 Trauner and Obwegeser's Inverted L Osteotomy. 1955.

Diagram 70 Schuchardt's Inverted L Osteotomy and Graft. 1961.

Diagram 71 Epker's Modification of the Superior Border Wire Placement for a Modified Sagittal Split Osteotomy. 1977.

Diagram 72 Booth's Inferior Border Wire Placement for the Sagittal Split Osteotomy. 1981.

Diagram 73 Epker's Modification of the Sagittal Split Ramus Osteotomy. 1978.

Diagram 74 Robinson's Graft to Caldwell & Letterman's Osteotomy. 1957.

Diagram 75 Caldwell & Amaral's Variation of Caldwell & Letterman's Osteotomy. 1960.

Diagram 76 Thoma's Graft to Verne, Polachek & Shapiro's Variation of Kostecka's Osteotomy. 1961.

Diagram 77 Robinson & Lytle's V Ramus Osteotomy. 1962.

Diagram 78 Caldwell, Hayward & Lister's Sliding C Ramus Osteotomy and Variations. 1962.

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Diagram 79 Eiselsberg's Step Body Osteotomy. 1906.

Diagram 80 Pehr Gadd's Step Body Osteotomy. 1906.

Diagram 81 Blair's Oblique Body Osteotomy for open bite. 1907.

Diagram 82 Eiselsberg & Pichler's Oblique Body Osteotomy. 1912.

Diagram 83 Nicolsky's (1912), Lindemann's (1920) & Bruhn's (1921) Reverse Step Body Osteotomy.

Diagram 84 Limberg's Sub-periosteal Graft Body Osteotomy. 1928.

Diagram 85 Ginestet's "Drawer" Body Procedure. 1939.

Diagram 86 Kazanjian's Body Slide Osteotomy. 1937.

Diagram 87 Dingman's Step Body Osteotomy for Retrusion. 1948.

Diagram 88 Pichler & Trauner's Reverse Step Molar Body Osteotomy for Retrognathism. 1948.

Diagram 89 Converse's Step Body Osteotomies for Retrusion. 1968.

Diagram 90 Trauner's Biangled Body Osteotomy. 1969.

Diagram 91 Mehnert's Variation Sada's Sagittal Split Osteotomy for Retrognathic Mandibles. 1972.

Lateral Deformity (Body Procedures).

Diagram 92 Eiselsberg's Symphysis Expansion Osteotomy. 1906.

Diagram 93 Sowray & Haskell's Symphysis Contraction Osteotomy. 1968.

Apertognathism.

Diagram 112 Eiselsberg & Pichler's Body Osteotomy for Open bite. 1912.

Diagram 113 Limberg's Subcondylar Osteotomy. 1925.

Diagram 114 Hensel's Oblique Ramus Osteotomy. 1937.

Diagram 115 Hensel's Pre-auricular Approach.

Diagram 116 Dingman's Horizontal Osteotomy for Correction of Open Bite Deformity. 1944

Diagram 117 Dingman's Approach for the Horizontal Osteotomy of the Ramus for the Correction of Open Bite. 1944.

Diagram 118 Winter's Angle Osteotomy. 1947.

Diagram 119 Pichler & Trauner's Inverted L Ramus Osteotomy. 1948.

Diagram 120 Hovell's & Pankow's Angle ostectomy. 1956/58.

Diagram 121 Immenkamp's Inverted L Ramus Osteotomy. 1957.

Diagram 122 Schuchardt's Inverted L Ramus Osteotomy. 1959.

Diagram 123 Obwegeser's Modified Sagittal Split Osteotomy I for Correction of Apertognathia. 1964.

Diagram 124 Obwegeser's Modified Sagittal Split Osteotomy II for Correction of Prognathism (shown) and recommended for Correction of Apertognathia. 1964.

Asymmetry (Condyle Procedures).

Diagram 125 Epker & Wolford's Condylectomy Using a Pre-auricular Approach. 1980

Diagram 126 Pettit & Walrath's Flail Joint Osteotomy. 1932.

Diagram 127 Rushton's Condylotomy and Graft for Correction of Condylar Agenesis. 1942.

Diagram 128 Hinds, Reid & Burch's Intra-oral Condylectomy. 1960.

Asymmetry (Ramus & Body Procedures).

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Segmental Arch Subapical Procedures.

Diagram 159 Hullihen's Subapical Osteotomy. 1848.

Diagram 160 Hofer's Subapical Osteotomy for Correction of Retrusion. 1936.

Diagram 161 Köle's Subapical Osteotomy for the Correction of Anterior Alveolar Deformities. 1959.

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Diagram 163 Petersen's Posterior Subapical Osteotomy. 1978.

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Diagram 165 Schuchardt's Anterior Subapical Osteotomy for the Correction of Open Bite Deformity, with Iliac Crest Graft. 1961.

Diagram 166 Bell & Dann's Multiple Anterior Subapical Osteotomies. 1973.

Diagram 167 Reichenbach, Köle & Bruckl's Anterior Subapical Osteotomy for Correction of Anterior Open Bite, using Symphysis Bone Graft. 1965.

Diagram 168 Bell & Dann's Anterior Subapical Osteotomy, with Midline Split, for Correction of Insufficient Arch Length. 1973.

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Diagram 169 MacIntosh's Total Subapical Osteotomy for the Correction of Skeletal Open Bite Deformity. 1974.

Diagram 170 Dietz, Gianelly & Booth's Total Subapical Sagittal Split Osteotomy for the Correction of Retrognathism. 1977.

Diagram 171 Epker & Wolford's Total Subapical Osteotomy. 1980.

Diagram 172 Epker & Wolford's Modification of the Sagittal Total Subapical Osteotomy for the Correction of Excessive Curve of Spee. 1980.

Diagram 173 Epker & Wolford's Modification of the Sagittal Total Subapical Osteotomy for the Correction of Deficient Lower Third of the Face Deformity. 1980.

Diagram 174 Piecuch & Tideman's Total Subapical Osteotomy for the Correction of Deep Bite Deformity. 1981.

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APPENDIX TWO.

Illustrations

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APPENDIX THREE

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APPENDIX FOUR

Glossary.

Authors

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APPENDIX FOUR

Glossary.

Subject

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VERTICAL OSTEOTOMY OF THE BODY

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VERTICAL OBLIQUE (SUBSIGMOID) SLIDING OSTEOTOMY

P: 81, 90, 163, 285

THE END

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