The Development of Surgical Procedures for the Correction of
Acquired or Developmental Anomalies of the Mandible.

A treatise in partial requirement for the degree of
Master of Dental Surgery.

Department of Oral Surgery, Oral Medicine,
Faculty of Dentistry,
University of Sydney.
1985.

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The Development of Surgical Procedures for the Correction of
Acquired or Developmental Anomalies of the Mandible.

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# Mandibular Surgery

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"Tactus Fühlung"
Copperplate engraving. Adrian Brouwer (1605 - 1638)
Illustration 1
*INTRODUCTION*

This treatise deals with the development of corrective jaw procedures of the mandible, that are increasingly being used today. This treatise will show the various stages through which have evolved the ostotomies and ostectomy of today.

The development of the surgery will be discussed in detail, taking its starting date from the forerunner of modern surgery relevant to this treatise, an American named Hullihen, who wrote in 1849 of the correction of an anterior open bite, which was the result of severe burns to the face and consequent scar contraction. The surgery was performed in 1846.

Since then a large number of various techniques have developed. According to their need, the degree of difficulty or the satisfaction of the results, these techniques over the years have been discarded or modified, either largely or in some small part. This treatise will show that there have been many parts of the mandible to come under the scrutiny of surgeons in the search for the ideal procedure for the defined problem. As surgery is intrinsically not without its problems, the search has been never-ending and will, of course, continue to strive for faster, better and safer procedures.

As in dealing with any historical material, some sources are reliable, and others as time lengthens into the past, become less reliable. Some of the older sources of information will be almost impossible to substantiate. The main reason for the limitations into researching into the past is twofold. Firstly the lack of good and reliable material. Secondly, suitable anaesthesia
was necessary for the development of these surgical procedures. It was not until the use of General Anaesthesia, from the middle of the 19th century, that major reconstructive surgery of the face could be and was undertaken. It was General Anaesthesia and satisfactory regional block anaesthesia that allowed surgeons the time and cooperation from the patient for the achievement of such delicate and often technically difficult surgery. The final reason for not going to any great extent into the past is that this is a surgical treatise and not an historical treatise. Referenced sources only where possible will be used.
The impetus for the development of surgery on the mandible came with the introduction of suitable anaesthesia. Although surgery in general was an established discipline, the Company of Surgeons being formed in 1745 in England, and still earlier in France in 1743, surgery was still limited in its extent and development by the lack of deep anaesthesia.

Scott of London in 1830 (Cartwright 1967) performed the first major piece of jaw surgery, unilateral excision of a mandible, and Hullihen of Wheeling, West Virginia performed the first correction of a mandibular deformity in 1846 both without the use of a general anaesthesia. Opium and alcohol, amongst other agents, had been used previously but it was not until the late 1800's that anaesthesia was generally accepted. It was substantially developed in the 1840's, but it took a royal birth, Prince Leopold son of Queen Victoria, in 1853 to finalise the acceptance of anaesthesia and collapse of opposition. It freed the patient from pain and lessened the risk of death from shock, usually the shock of pain (Vagal Inhibition). But most importantly, something not realised for some time, it allowed the surgeon greater operating time, and freed him to develop new techniques.

Consequently it was not until towards the end of the 19th. Century that reports of surgical advances for the correction of jaw deformities began to appear. To be followed soon after by reports, not of a single procedure, but of a series of procedures.
In view of the complexity of many of these procedures, and the prolonged nature of many of them, it should not be surprising that these techniques should have taken so long to develop. This coupled with the general ignorance of the nature of developmental deformities, which were often thought to be the result of 'God's displeasure' and it becomes understandable why the procedures were so slow in developing. However once these initial obstacles were overcome then advances came rapidly.

The effect of antisepsis, introduced by Lister, did not have the same effect on the development of surgical techniques as did general anaesthesia. With the mortality rate at an acceptable level (post anaesthesia to pre-antibiotics), the cosmetic and functional results from surgery was considered sufficient reward for the surgery when balanced against the high post-operative infection rate. However it was not until the introduction of antibiotics that the problem of sepsis could be controlled to a far greater degree. Reports of sepsis in otherwise successful operations were often noted in the early 20th. century. However as can be seen, this did not substantially hinder the development of techniques, although certainly cast a sour note over their success. What antibiotics did allow was the advancement and more frequent use of extra-oral approaches.

Surgery on the mandible for the treatment of developmental deformities can be divided into several areas. Rowe (Rowe 1960) divided the areas of surgery into:

1. Correction of mandibular retrusion.
2. Correction of mandibular protrusion.
3. Correction of apertognathia.
4. Correction of unilateral retraction.
5. Correction of Unilateral macroglossia without protrusion.
6. Correction of unilateral micrognathia without retraction.
7. Correction of excessive curvature of the lower border or depth of the mental prominence.

Bell (Bell, Proffit & White 1980) had a much simpler breakdown of the areas that were considered as part of deformity surgery of the mandible. Like Rowe he based his classification from the point of view of the problem to be corrected. These were:

1. Mandibular deficiency.
2. Mandibular excess.
3. Open bite.
5. Mandibular asymmetry.

Epker's (Epker & Wolford 1980) classification varies from Bell and Rowe in that the classification is determined from the area of the mandible having the surgery performed rather than the nature of the problem:

1. Segmental surgery.
2. Ramus surgery.
5. Alloplastic augmentation surgery.

While it is simpler from a classification viewpoint to divide the surgery into the anatomical areas that are being surgically worked on, this is not how the surgery developed. The
motivation for the surgery came from the problem. What came about was there were often several, and even conflicting, ways that a single problem could be solved. This was best demonstrated in the early days when Blair advocated correction of mandibular prognathism through body procedures and advised that this was the best and only way to correct the problem, while Babcock was advocating ramus surgery for the correction of the problem and suggested that this was the proper way for the problem to be corrected.

If the development of surgery is to be examined, then it is probably best that the techniques be looked at in the light of the problems that prompted the development of the techniques. Hence the classification employed will be based on a problem type.
MANDIBULAR SURGERY

MANDIBULAR PROGNATHISM

Condyle procedures

Introduction.

The first procedures, in general, that were developed for the correction of prognathism were condyle procedures, condylectomy in particular. The initial attempts, in the late 1800's, were rather crude, with destruction of the condyle, but they gave an immediate result. The condylectomy procedures followed earlier reports of the success of condylectomies for the correction of asymmetry deformity caused by condylar hyperplasia or tumour. French surgeons attempted to adapt the same principles to the treatment of prognathism and modified them in the process. In their initial reports the surgeons destroyed the condyle rather than removed it, and reset the mandible posteriorly.

Subsequently, in the early 1930's, condylootomy procedures were used. The condyle was sectioned at the neck, usually via a blind approach with a Gigli saw, and the mandible retracted. The procedure was first reported for the correction of apertognathia (open bite deformity) but was better suited for the correction of prognathism, especially where anterior closed bite was also a part of the problem. This procedure had the disadvantage of producing open bite post-operatively. However there were several initial advantages for making the technique initially popular. The operation was of a short duration, and there was minimal scarring.
Condylectomy with grafting to produce a new joint was subsequently developed in the middle 1940's, in order to overcome the problems of joint dysfunction post-operatively. These procedures made use of a direct, posterior border approach. This approach was modified and the use of grafting declined with later reports into the 1950's. This procedure is better discussed in the chapter on Asymmetry.

Prognathism was a problem that early authors felt should be solved by undertaking the surgical correction at the presumed source of the growth, the condyle.

Discussion.

The first reports for the correction of mandibular prognathism came from the French literature in fairly rapid succession. Jaboulay, Berger and Bérard were the pioneers of this procedure used for the correction of prognathism. The procedure was the bilateral destruction of the condyle via an external preauricular approach. (Jaboulay 1895, Berger 1897, Jaboulay & Bérard 1898.). The condyle was destroyed with chisels rather than surgically removed or sectioned. The mandible was then reset posteriorly.

Dufourmentel went on to report, nearly thirty years later, on a series of bilateral condylectomies for the treatment of prognathism. The study, again reported in the French literature, was a short term report of the immediate post-operative phase. Dufourmentel noted a very high success rate for his series. (Dufourmentel 1921).

By 1932, Dufourmentel was still vigorously
sponsoring condyle resection for the correction of prognathism while elsewhere in Europe, and Germany in particular, surgeons were developing body procedures and ramus procedures for the correction of prognathism. (Dufourmentel & Darcissac 1932). The nearest to a long term study at the time was by Baeau (Barea 1921) who was perhaps inspired by Dufourmentel to write a treatise on the treatment of prognathism by resection of the condyle. The treatise was in favour of condyle resection and for its continuation in the treatment of prognathism.

However by the middle 1930's, reports began to appear arguing against the operation. Two in particular were very exhaustive critiques. (Landais 1934, Bourguet 1935). The major objection to the procedure was the often painful, often permanent, very limited function of the joint after the surgery was performed. The next objection was the limited number of indications for the surgery in order to achieve satisfactory results. These indications were:

1. Mild prognathism.
2. Combined with posterior (molar) open bite.
4. Normal arch shape.

If the prognathism was present alone or to a greater degree than the posterior open bite, then anterior open bite resulted post-operatively. Ramus forshortening was the cause of the open bite development. The correction of mandibular retrusion was not indicated. If used without the correct indications, the malocclusion often became worse.
Kostecka's Subcondylar Osteotomy for the Correction of Open Bite Deformity.
From Kostecka 1934. After Kostecka 1931.

Diagram 1

Reports in favour of the procedure coming from France markedly dropped off after that time (mid 1930's).

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 open bite deformity. See diagram 1. Kostecka used a Gigli saw for the procedure using the blind approach that will be described in detail in the chapter on Prognathism. Kostecka did not use the procedure for the correction of prognathism although it was better
suited for the correction of prognathism than open bite, as it tended to produce an open bite post-operatively. It was best suited to prognathism that was accompanied by closed bite. Caldwell & Gerhard (Caldwell & Gerhard 1979) reported that there were several advantages to the procedure including the approach (that made it an improvement to the condyle resections previously mentioned) and they were:

1. The simplicity of the operation.
2. The short duration of the procedure.
3. Minimal scarring from the (external) approach used.
4. The instruments required were readily available.
5. Fixation required need not be elaborate as immobilisation need not be more than six to eight weeks.
6. Teeth are not sacrificed to achieve the result.

Disadvantages were:
1. Lack of control over the fragments once they were sectioned.
2. The open bite that developed post-operatively.
3. The high complication rate.

Complications associated with the blind approach to the condyle were salivary fistula, gustatory hyperhidrosis, and damage to major nerves and vessels in the area especially the facial nerve (the latter producing possible and certainly temporary facial paralysis). (Caldwell & Gerhard 1979).

Condylotomy was still being advocated by Gonzalez-Ulloa in 1951 (Gonzalez-Ulloa 1951). Gonzalez-Ulloa recommended an incision that curved superiorly and anteriorly from the middle of the tragus. See diagram 2. Thus the Facial nerve was
Gonzalles-Ulloa's pre-auricular Approach.
From Gonzales-Ulloa 1951.

Diagram 2

avoided and also the Superficial Temporal artery most of the time. Due to the often tortuous nature of the artery, it was impossible to avoid it all the time. Gonzalez-Ulloa also devised special instruments to extract the head of the condyle after resectioning and at the same time protect the Internal Maxillary artery, haemorrhage from which can be difficult to control. See diagram 3. No intermaxillary fixation was applied by the surgeon, instead early function was encouraged, within days of the procedure. The relapse
rate as regards to open bite formation was not reported.

Converse and Shapiro (Converse & Shapiro 1952) reported a condylectomy in which the head of the condyle was removed in a manner similar to Rushton, using a modified Gonzalez-Ulloa approach. Unlike Rushton, the head was not replaced with a graft. Converse advocated this procedure for the correction of mild to moderate prognathism. More severe forms of prognathism required other procedures.

There have been other reports since by Hovell (Hovell 1956) and Taylor and Cooke (Taylor & Cooke 1958) who both gave indications of mild prognathism and a normal to acute gonial
Authors' new method of removing parallelepipedonal bone section from region of sigmoid notch.

Protruded lower jaw carried backward to approximate coronoid process and condyle. (Research is being continued by this method and the technical data will be published later.)

Smith & Johnson's Subcondylar Osteotomy. Bony cuts and final position.
From Smith & Johnson 1944.

Diagram 4

angle as the indications for the procedure. If there was a molar open bite, then this also was an indication. Since those reports the procedure appears to have fallen into disfavour as there has been little noted reference to it.

Smith and Johnson, in a review of the surgical treatment of mandibular deformities, suggested a variation of condyle surgery for the correction of prognathism that avoided most of the complications of the blind approach suggested by Blair (1907) and later Kostecka (1928). The technique consisted of the removal of a notch of bone (a parallelepipedonal section) just anterior to the condyle neck at a tangent to the lowest curvature of the sigmoid notch. See diagram 4. The condyle was then sectioned off using a Gigli saw under direct vision. The notch that was cut allows the mandible to be slid along this 'track' of bone while the condyle
stays in its position in the glenoid fossa. The mandibular setback is limited to the amount of bone removed at the notch. The mandible is then slotted in to the condyle and the fragments wired together.

The procedure above was performed through an external approach. A 2.5 centimetre incision is made commencing over the condyle and proceeding inferiorly over the posterior border of the ramus. Blunt dissection is used subcutaneously down to the lower border. No cases were reported as the procedure was still new. (Smith & Johnson 1940). See diagram 5.

Nearly 15 years later Smith and Robinson evaluated their cases, and their results. Their intended approach had been modified in that the incision now started 5 centimetres anterior to the ear, 1 centimetre above the hairline, and extended obliquely downwards towards the helix of the ear and then inferiorly and anteriorly to the ear to end as a small curve $\frac{1}{4}$ centimetre behind the lobe. See diagram 6. The incision was through skin only and the subcutaneous dissection was blunt, directly over the subsigmoid notch. The bone was removed using a template. Interdental eyelet wiring was used for intermaxillary fixation. The anaesthesia of choice was combined local infiltration and regional block anaesthesia.

Smith and Robinson advanced a number of arguments for their procedure.

1. No sacrifice of teeth.
2. No large amount of bone loss.
3. There are no large nerves or blood vessels in the sectioned bone.
Smith & Johnson's Original Pre-auricular/Posterior Border Approach.
After Smith & Johnson 1944.

Diagram 5
Smith & Robinson's Modified Pre-auricular Approach.
After Smith & Robinson 1955.

Diagram 6
Diagram 7

4. Muscles of the floor of the mouth are not disturbed.
5. Temporomandibular joint ligaments are not involved.
6. Osteotomy site is not disturbed by the masticatory muscles.
7. Tongue space is relatively undiminished compared to body procedures.
8. Condyle function is not disturbed.

These advantages are in gross distinction to the Pettit and Walrath arthroplasty, which has been called the "flail" joint technique, (Pettit & Walrath 1947) for the correction of asymmetry, see diagram 7, (See Asymmetry for more detailed explanation) or the more destructive condyle resection of Jaboulay for example.

The follow-up of Smith and Robinson after nearly fifteen years showed good results with little relapse. However no
quantitative studies were done. (Smith & Robinson 1955).

When condylectomy is indicated such as for an osteochondroma and there is little prognathism or 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. (Epker & Wolford 1980). Generally a graft would not be required for the correction of prognathism unless the ramus were severely affected by disease.

Summary.

Condyle procedures for the correction of prognathism are limited and hence the reports are relatively fewer compared to ramus procedures. The indications for either condylectomy or condylotomy for the correction of prognathism are limited to:

1. A mild degree of prognathism.
2. A normal gonial angle.
3. A normal mandibular arch.

The advantages of the condyle procedures for the correction of prognathism were:
1. The simplicity of the operation.
2. The short duration of the procedure.
3. Minimal scarring, especially where the blind approach is used.
The advantages were the main reason why condyle procedures have not completely died out, although very much in decline since they were first used for the correction of prognathism.

It was the disadvantages, most of which were post-operative, which were the reasons for the decline of the procedures. The result was often the substitution of one deformity for another, and hence other methods came to be preferred. Disadvantages were:

1. Lack of control over the fragments once they were sectioned.
2. The open bite that developed post-operatively.
3. The high complication rate.

Complications associated with the external preauricular approach to the condyle were salivary fistula, gustatory hyperhidrosis, and damage to major nerves and vessels in the area especially the Facial nerve.

There has been a gradual decline in the number of reports for the correction of prognathism using condyle procedures. Most reports have concentrated on ramus and body procedures.

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MANDIBULAR PROGNATHISM

Ramus Procedures

Introduction.

The treatment of prognathism using ramus procedures was not as rapid in developing as the body procedures for the same problem. Most of the rapid advances came in the development of body procedures. Gradually into the 1920's came the reports that showed the development of ramus procedures for the correction of prognathism.

The procedures started with the simplest horizontal osteotomies and gradually became more refined with angled and oblique sections that attempted to give more stability and greater union potential with less complications. The simple and later varied horizontal osteotomies gave way to two distinct trends in surgical procedures. The sagittal osteotomies and the vertical osteotomies. Both have their advocates and their critics. Both aim to achieve a procedure that is as safe as possible, with the minimum of complications and the most stable and satisfactory of results. It would appear from the literature that the vertical osteotomies do have the better record for results with the minimum of complications even though the acceptance of the vertical series of procedures is by no means universal at this stage. The range of variations and modifications of these basic procedures would indicate more the present unsatisfactory state of the art than purely surgical ingenuity.
A variety of external approaches were tried initially, blind approaches were first suggested by Blair (Blair 1915) and external approaches suggested by Babcock (Babcock 1909). It was not until the 1930's that the Risdon approach (Risdon 1934) from the lower border was used. The oral approaches were slower to start than the external approach due to the fear of infection. The oral approach has gradually become the favoured approach for many procedures, along with the Risdon (external approach). Generalising, the external approach seems to be favoured by those using the vertical ramus procedures, and the oral approach for those using the sagittal ramus procedures. This is by no means a hard and fast rule.
Babcock's Preauricular Approach.
Discussion

Development of the Horizontal Ramus Procedures.

Babcock (Babcock 1909) was the first to use a ramus procedure for the correction of prognathism. The procedure was performed in 1908 and was a horizontal osteotomy. See diagram 8. The procedure was performed via an external incision that ran from "the zygoma to a point under and anterior to the angle of the jaw," over the posterior border of the ramus. The dissection was carried out bluntly from the subcutaneous tissues around the parotid gland, around the facial nerves and through the masseter muscle to the posterior border. See diagram 9. The ramus was divided by a chisel care being taken to avoid sectioning the neurovascular bundle. Babcock did not mention whether this was successful or not. The fragments were not wired in the new position, but the teeth were. The interdental wiring was subsequently found to be inadequate and replaced with a cast dental splint. This too was found to be inadequate and was supplemented with the use of a chin cup with elastic traction to a headpiece. This was found to be adequate and traction was applied for nine weeks.

Blair (Blair 1915) noted that Babcock advocated and used this procedure for the correction of protrusion, which Blair did not agree with. Babcock's report examined a number of theoretical ramus operations, predicting their use for various mandibular deformities. See diagram 10. One such operation was a subcondylyar operation similar to Kostecka's procedure (Kostecka 1928), see diagram 11, which Babcock felt was not a suitable procedure for the correction of prognathism as there would be a tendency for pseudoarthrosis. Similarly Babcock discussed a theoretical operation at the angle of the mandible that was later performed by Winter. See
Diagram showing a condition of mandibul intrusion, the dotted lines indicating various directions in which the ramus may be divided in order to overcome the deformity.

Babcock's Variations on Ramus Osteotomies. From Babcock 1909.

Diagram 10

Diagram 12. This operation divided the Mandibular neurovascular bundle (Winter 1947). Babcock recommended that this procedure would be best indicated for the correction of laterognathism (asymmetry of the mandible). A vertical section similar to Caldwell and Letterman (Caldwell & Letterman 1954) procedure was also discussed, see diagram 13. Babcock did not approve of this operation as he felt that there would be marked posterior displacement of the posterior fragment leading to poor healing and destruction of the angle of the mandible. Babcock was not to know that this problem would be overcome by overlapping the fragments and securing them with wire. Interosseous fixation using wire was unacceptable practice at the time for many surgeons, due to the greater possibility of infection and slower or poorer healing. On the procedure that he used, Babcock noted that in future he would use ivory or metal plates to splint the ramus over the lateral aspect of the ramus. This would help overcome
Result of correcting the deformity by a section through the base of the condylar process. This line of section reduces the leverage of the temporal muscle, and from lack of fixation of the smaller fragment would seem to involve a greater tendency to pseudarthrosis than certain other lines of section.

Babcock's Forerunner of Kostecka's Subcondylar Osteotomy.
From Babcock 1909.

Diagram 11

Result of a section between the rami and the body of the jaw. The inferior dental canal is divided, the angle of the jaw increased, and the section is not so well adapted for the correction for prognathism. For lateral displacements of the jaw, this line of division, made on the side of the displacement may be useful.

Babcock's Forerunner of Winter's Angle Osteotomy.
From Babcock 1909.

Diagram 12
Result of a vertical division of the rami. This line of section enters the body of the temporal muscle by approximating the coronoid and condylar processes and tends to cause a marked posterior displacement of the lower part of the smaller fragment.


Diagram 13

the ramus forshortening that Babcock noted he experienced with his first case.

It was not until 1915 that Blair used a combination of ramus and body procedures for the correction of prognathism on a particularly severe case (Caldwell & Letterman 1954). Blair (Blair & Ivy 1923) reported using a horizontal ramus osteotomy for the correction of prognathism, using a blind external approach with a Gigli saw identical to the approach later described by Kostecka (Kostecka 1928) and seemingly attributed to Kostecka. Previously Blair (Blair 1909) felt that correction of prognathism was best corrected by body procedures alone.
There were a number of problems with the horizontal ramus osteotomy. Hogeman (Hogeman 1951) in a review of one hundred and seventy one cases of horizontal ramus osteotomy showed problems with relapse (23% unsatisfactory); with decreased mandibular opening; with increased Temporomandibular joint dysfunction; Facial nerve damage (38%); Mandibular nerve damage (31%); and with gustatory sweating (9%). Despite this, Hogeman reported that 98% of his patients were happy with the result. (Hogeman 1951).

The horizontal osteotomy was gradually refined by a number of surgeons using different approaches. A lateral approach, sometimes called the 'Swedish Technique', which involved sectioning the ramus from its lateral aspect either blindly or by direct vision, the latter using a key-hole type saw, was advocated by such surgeons as Bruhn (Bruhn 1920) and Aleman (Aleman 1921) who used an oral approach, and Lindemann (Lindemann 1936) and Ragnell (Ragnell 1938a) who preferred an extra-oral approach.

The authors mentioned in the above paragraph used either an oral approach incising over the anterior border of the ramus, or if the approach was external to use a technique described by Blair (Blair & Ivy 1923) and later by Dingman (Dingman 1944a) and detailed later below, and modified by the surgeons below.

Schmidt (Schmidt 1929) and Wyner (Wyner 1929) were the first to use a direct vision approach to the ramus through the side of the face, as described below by Hensel. Hensel does attribute part of his procedure to Schmidt and Wyner.
Hensel's Preauricular Approach.

After Hensel 1957.
Hensel (Hensel 1937) described two approaches to the ramus. One his own, see diagram 14, and the second belonging to Schmidt (Schmidt 1929) and Wymer (Wymer 1929), see diagram 15, both of Munich. The bony section in all cases was a horizontal osteotomy of the ramus. Schmidt's approach required an incision of about 1½ inches extending forwards and obliquely upwards from the middle of the lobe of the ear, heading towards the outer canthus of the eye. The approach from then on was basically a blunt one around the parotid gland, to expose the upper part of the ramus.

Hensel's approach was a horizontal incision across the cheek at the level of the lowest part of the lobe. The facial incision commenced 1½ inches from the lobe and proceeded towards the lobe until a point 3/8ths of an inch is reached from the lobe at which stage the incision proceeds down vertically for a length of 1½ inches also. Hensel noted no complication with this approach. The remainder of the approach was by blunt dissection as before.

The medial approach, sectioning the ramus from its medial aspect outwards, was developed by surgeons such as Ernst (Ernst 1927), Ginestet (Ginestet 1939) and Skaloud (Skaloud 1951) who all preferred an oral approach, and Kostecka (Kostecka 1928), Kazanjian (Kazanjian 1936), Dingman (Dingman 1944a) and Clarkson (Clarkson 1955) who recommended the external approach, along with Goldstein (Goldstein 1947) who reviewed ramus procedures in 1947. The oral/medial approach was performed by Moose (Moose 1945) using special retractors and saws that he developed for especially for this approach. In Moose's opinion the procedure should not be performed routinely due to difficulty of adequate access even with special retractors and saws.
The blind external/medial approach was reported by Kostecka (Kostecka 1928) who described an oblique cut of the full width of the ramus. See diagram 16. The bony cut extended the full width of the ramus in the anterior-posterior direction from a point high on the anterior border of the ramus to a point on the posterior border inferior in height to the initial cut. The sectioning was done by a Gigli saw threaded through two incisions, one over the anterior border of the ramus and the other over the posterior border, by an introducer which in this case was an aneurysm needle. Kostecka was not the first to use the blind approach nor the first to use an angled horizontal cut of the ramus. But he was the first to combine the two.

Both Ernst (Ernst 1927) and Ginestet (Ginestet 1939) used the angled cut described by Kostecka but instead used a subperiosteal medial approach that was intra-oral instead of Kostecka's blind external one. Since Ernst performed this procedure and wrote of it by 1927, before that of Kostecka (1928), he must take credit for the procedure. Kostecka's blind external approach was first described by Blair in 1915 and again in 1923 (Blair 1915, 1923) for ramus osteotomy correction of mandibular retrusion and later protrusion.

Kostecka was also to write of a blind subcondylar procedure for the correction of open bite (Kostecka 1931) and later adapted by others (Schaefer 1941, Reiter 1951) for the correction of prognathism. This will be discussed later in this chapter in the section on vertical ramus procedures, and also in the chapter on Apertognathia (Open Bite).
Incision made along posterior aspect of ascending ramus just above the angle of mandible.

Large curved anoscopic needle passed through incision to emerge through a corresponding incision made along the anterior aspect of the ascending ramus.

Kostecka's Oblique Horizontal Ramus Osteotomy.

Diagram 16
Gigli saw attached to eye of aneurysm needle with steel wire.

Aneurysm needle to bring the Gigli saw through the inferior incision and to place it in contact with the medial aspect of the ascending ramus.

While sectioning the mandible, saline solution should be directed toward each incision to prevent overheating of the Gigli saw. This procedure is performed bilaterally.

Kostecka's Oblique Horizontal Ramus Osteotomy. (Cont.)
Anatomic repositioning of Gigli saw to medial aspect of the ascending ramus.

Diagrammatic sketch showing new position. The body of the mandible is in medial relationship to the ascending ramus.

Kostecka's Oblique Horizontal Ramus Osteotomy.
From Kostecka 1928.

Diagram 16
Diagram 17

The advantage of the oblique cut over the horizontal cut was to help decrease (but not to eliminate) the effect of muscle pull thus reducing forshortening of the ramus height. Also to marginally increase the area of bony contact thus decreasing the chance of non-union, and also the time taken to achieve union. This use of the oblique cut was endorsed by Dingman (Dingman 1944a+b) who suggested that the obliquity of the cut could be varied to produce a simultaneous opening or closing of the bite depth. See diagram 17. If the section cut on the anterior border is higher than the posterior border cut and the mandible is then retruded, the effect will be to open the bite where the angle of incline is followed. Should the anterior section-cut on the anterior border be lower than the end-cut on the posterior border, then a closing of the bite will be accomplished for a similar retrusion of the mandible. (After Dingman 1944a+b).
Clarkson’s review of the blind approach of Kostecka listed arguments against the use of the procedure:
1. The recurrence of open-bite post-operatively (due to the pull of Medial Pterygoid and Masseter on the distal fragment, and the rotation effect of Lateral Pterygoid).
2. The high percentage of non-union cases (due to upward pull of Temporalis and the thinness of the mandible at the section site).
3. The large percentage of cases with anaesthesia of the lip.

Clarkson’s review also encompassed the use of body procedures. He listed the disadvantages of body procedures used for the correction of prognathism:
1. Body procedures have prolonged healing time compared to ramus procedures.
2. The loss of teeth required for the surgical access to the body osteotomy site.
3. The occasional but severe neuritis found with body procedures.
4. The greater degree of lip anaesthesia found.
5. The occasional post-operative relapse.

While Clarkson used an external blind approach performing the ostectomy from the medial aspect outwards after Kostecka, he did not favour it for his future work. He still favoured the use of ramus procedures for the correction of prognathism over the use of body procedures. (Clarkson 1955)

Knowles et al (Knowles, Kernahan & Burston 1963) in a report on a new way of determining precision sectioning with a template on ramus procedures for the correction of prognathism, noted
similar disadvantages to Clarkson for the blind approach to ramus procedures:

1. Damage to the Mandibular nerve.
2. Delayed or non-union possibility is high.
3. Poor contact of fragments.
4. Anterior open bite often seen.
5. Ramus forshortening often noted.

Knowles et al. went on to give the advantages of direct vision over indirect vision.

1. Fragments can be wired.
2. Mandibular nerve can be better avoided.
3. The section cut can be better planned and executed.

Goldstein's review (Goldstein 1947) compared the horizontal ramus section to the vertical oblique sliding ramus section and to the condyle head section. Goldstein noted that reasonable results were obtained by all three procedures as seen over a four year period. Goldstein did note his preference for condyle procedures over any of the ramus procedures.

A similar review was performed by Thompson and Jurgens (Thompson & Jurgens 1956) nearly ten years after Goldstein. It was noted that the number of procedures developed indicates that no one procedure has been completely satisfactory and there are therefore advantages and complications associated with all procedures. However in comparison they noted that of the ramus procedures the blind and extra-oral approaches were the most hazardous with possible damage to the facial nerve, the internal maxillary artery, the temporal arteries and the parotid gland. The
intra-oral and combination intra-oral and extra-oral approaches were considered the best for the ramus procedures, the Skaloud (Skaloud 1951) combination approach was considered the best. Of the body procedures the Dingman procedure was considered the best, with the disadvantage of loss of teeth and loss of mandibular nerve function, but with the advantages of being able to greatly decrease or even eliminate post-operative open bite and also being able to control the fragments more easily than with ramus procedures. The subcondylar procedures, (after Kostecka), were the most satisfactory of the procedures with fewest post-operative complications being reported, and the "Bow Back" procedure of Pettit and Walrath (Pettit & Walrath 1947) being considered unnecessary. On the balance Thompson and Jurgens considered that prognathism was best corrected by a ramus procedure preferably of an oral or oral/extra-oral combination approach.

In 1944 Dingman (Dingman 1944b) had recommended that the horizontal osteotomy of the ramus be performed above the level of the lingula to preserve the neurovascular bundle. In order to ensure this and allow the fragments to be wired for greater security, he recommended a posterior border external approach approaching the posterior border directly with a preauricular approach previously described. Dingman recommended this procedure for the correction of either prognathism or retrognathism. The angle of the cut, as previously mentioned, could be varied from the horizontal if there was an accompanying open or closed bite deformity. (Dingman 1944b). This recognition of the importance of the neurovascular bundle and that efforts should be made to preserve it, was a major step in the development of subsequent procedures, and an indication of the direction of clinical research at the time.
Intraoral Incision.
Opening of the pterygomandibular space.

Fitting of the ligature needle.

Attaching the rongeur saw.

Skaloud's Horizontal Ramus Osteotomy.

Diagram 18
Diagram 18

Skaloud's Horizontal Ramus Osteotomy. From Skaloud 1951.
Skaloud's procedure was also a horizontal osteotomy of the ramus developing an oral approach the forerunner of the approach used by later surgeons such as Obwegeser, and also using a new method of interosseus fixation for the horizontal osteotomy. Skaloud's fixation was with the use of direct osseus wiring via an oral approach. Unlike previous use of the Gigli saw blind approach, Skaloud's approach made use of an oral exposure of the anterior border of the ramus both medially and laterally. The Gigli saw was passed through the oral incision medial to the ramus and exited through a stab incision externally approximately half a centimetre below the ear lobe and posterior to the posterior border of the ramus. Unlike Archer, Skaloud avoided the mandibular neurovascular bundle by this oral exposure and passing the saw lateral to the bundle. This same approach enable Skaloud to wire the fragments together by looping a wire around the sigmoid notch and through the inferior fragment at the anterior border. It was unusual to attempt to wire the fragments after a horizontal ramus osteotomy, and the approach was the forerunner of the oral approach to be developed by later surgeons such as Obwegeser. See diagram 18. (Skaloud 1951). How simpler it would have been with the use of Lindemann burs instead of the Gigli saw which was not to be so until introduced by subsequent surgeons.

Development of the Sagittal Ramus Procedures.

The separation of this development stage is artificial but serves only to distinguish the two main current surgery schools. The development of the sagittal procedures was essentially European in the early stages, but a clear cut distinction is not readily made.
By 1942 Schuchardt (Schuchardt 1942) reported on his changeover to a differently angled horizontal osteotomy. Two bony cuts were made, one above the other on the lateral and medial surfaces of the ramus, and both above the lingula. The cuts were horizontal and were jointed up by an angled sectioning through the bone. See diagram 19. From the lateral, or medial aspect, the osteotomy was a horizontal procedure but from the sagittal aspect the procedure was an angled one. In 1954 (Schuchardt 1954b) Schuchardt reported a refinement of the angled cut to a step-like cut where the medial and lateral cuts were jointed by step sectioning similar to a mortice wood cut. See diagram 20. Schuchardt reported that he used these techniques through both oral and extra-oral approaches.
Schuchardt's Step Ramus Osteotomy. 1954.
From Schuchardt 1961.

Diagram 20

The angled procedure (angled in the coronal plane as distinct from oblique sectioning in the anterior-posterior plane) had been reported by Kazanjian (Kazanjian 1951), see diagram 21, using an extra-oral approach and before that by Ponroy and Cabrol (Ponroy & Cabrol 1948) in the French literature. Both recommended the procedure so that the action of both pterygoids could be resisted, stopping medial rotation of the condyle and loss of bony contact. The lateral cut was made lower than the medial cut. The bony cut could also be oblique in the anterior-posterior plane with the anterior cut being higher or lower than the posterior cut.
Kazanjian's Angled Ramus Osteotomy.
From Kazanjian 1951.

Diagram 21

The angled procedure had the disadvantage that the fragments often overrode each other leading to fragment forshortening, sometimes to a greater degree than the purely horizontal osteotomies because of slipping of the fragments with no hold on each other due to their angled nature. Schuchardt (Schuchardt 1954b) and
Trauner and Obwegeser (Trauner & Obwegeser 1957) claimed more reliable results if the fragments were wired. The advantage of the angled sections was, in general, union of the fragments was more reliable due to the larger area of bony contact.

Despite these gradual refinements to the horizontal osteotomies for the correction of prognathism, there are several inherent disadvantages. The pull of both lateral pterygoid and temporalis produced a superior and medial displacement of the superior fragment. A superiorly directed pull on the inferior fragment by the medial pterygoid - masseter sling produced a loss of posterior vertical dimension which in turn tended to produce a post-operative open-bite, even where there was none previously. Other complications included temporary or permanent anaesthesia, facial palsy, auriculo-temporal syndrome (Frey's syndrome), profuse or even dangerous haemorrhage, parotitis, parotid fistula, Temporomandibular joint dysfunction, osteitis, even osteomyelitis along the resection line, and pseudoarthrosis. (After Trauner & Obwegeser 1957).

For the majority of these operations where an extra-oral approach was required, a posterior border approach, first described by Blair (Blair 1915) and later in more detail by Dingman (Dingman 1944a), was used. See diagram 22. The incision was between 1 to 2 centimetres long immediately behind the posterior border commencing from the angle and proceeding vertically. The incision was cutaneous only. Blunt dissection was carried out to the parotid gland taking care to do minimal damage to the facial nerve as well as the parotid gland. In distinction to Blair's description, if the mandible was to be directly sectioned as opposed to a blind sectioning, the periosteum was incised and special retractors used to
expose either the medial or lateral surface of the ramus as needed.

This procedure is in contrast to the direct access technique described by Risdon which will be discussed later. (Risdon 1934).

Hovell (Hovell 1956) in a review of available procedures for the correction of facial deformities, recommended a variety of procedures suitable for the correction of prognathism. Hovell did not favour the intra-oral use of procedures and favoured the direct external approach for osteotomy on either the body or the ramus according to the case. Either a Risdon-type approach or a preauricular-type approach as described above by Dingman was used.
It was Hovell's opinion that intra-oral approaches allowed an unnecessary introduction of infection.

Hovell was of the firm opinion that a very careful observation of the individual case was necessary as a standard approach to solving prognathism problems, using standard techniques was not justified. Each case was to be examined on its merits, and the procedure that achieved the most satisfactory result was the procedure best indicated. Rather than trying to fit the patient for the procedure, often to achieve particular aims and to test new procedures, the procedure should be chosen to achieve the best possible result for the patient.

As already mentioned, in 1954 Schuchardt (Schuchardt 1954b) reported a refinement on his angled horizontal osteotomy that was a step-like cut that connected two horizontal ramus cuts. The medial cut was approximately 1 centimetre superior to the lateral cut and both were above lingula. Schuchardt reported that the approach that he used could be either oral or extra-oral.

Schuchardt's procedure must be considered the forerunner of a procedure reported in 1955 by two surgeons, Trauner and Obwegeser from Austria and Switzerland respectively. (Trauner & Obwegeser 1955, 1957). This basis has been acknowledged. (MacIntosh 1981). The technique described was to assume a dominance in the literature, in its many forms, for the next two decades. The procedure required two bony cuts nearly 2½ centimetres apart, one medial cut above the level of the lingula and one lateral cut below the level of the lingula.
Obwegeser's Sagittal Split Ramus Osteotomy.
1955.

Diagram 23

See **diagram 23**. The two cuts were then joined together by a series of bur holes. The bur holes were joined together, the holes having been drilled to a depth just below the cortical bone of the anterior aspect of the ramus. An osteotome was used to fracture the ramus along this oblique sagittal plane. The cleavage plane was supposed to be naturally lateral to the neurovascular bundle. The superior fragment remained in its original position and the inferior - anterior fragment was freed to be mobilised anterior or posterior to its original position as required. (That is, the correction of either protrusion or retraction). The technique could also be adapted to rotate about the angle for the correction of open or closed bite.
This surgical technique, performed intra-orally, achieved an immense increase in bony surface contact to allow some remarkably rapid healing times. The technique also allowed a greater degree of correction latitude, but was still seen to produce in some cases a marked degree of ramus forshortening due to the pull of the medial pterygoid - masseter sling.

According to Dal Pont (Dal Pont 1959, 1961) this technique was based on two previous techniques. Kazanjian's technique of obliquely sectioning the ramus through two horizontal cuts (Kazanjian 1951), [but which this author is of the opinion was more likely based on Schuchardt's same procedure taking into consideration both the origin (European) of the techniques of both Schuchardt and Trauner, and that Schuchardt's report precedes Kazanjian's by nearly a decade (Schuchardt 1942)]; and secondly on Schuchardt's later step-like osteotomy joining the same two horizontal cuts as the Schuchardt/Kazanjian.

Dal Pont was of the opinion that Obwegeser's and Trauner's technique constituted a far better technique than either of its predecessors. Both Converse (Converse, Horowitz & Wood-Smith 1968) and Trauner and Obwegeser (Trauner & Obwegeser 1957) acknowledge this with a reference to Schuchardt's role (Schuchardt 1954a). By 1954 Schuchardt (Schuchardt 1954b) was himself advising that the horizontal osteotomies he described be best done through an oral approach instead of the posterior border approach that he had previously been describing, and making more use of burs and chisels rather than bony saws that best went with the posterior border approach.
By 1961 Schuchardt was almost using the same technique as described by Trauner and Obwegeser (Schuchardt 1961).

The Trauner and Obwegeser technique required sagittal splitting between the two section cuts because of the distance between the cuts. The splitting, as distinct from sectioning, was a variation which was not necessary between the cuts described by Schuchardt in his step osteotomy. Trauner and Obwegeser also give credit, without saying why, to "Perthes-Schlossman" for help in the development of their technique, but no reference is given. However examination of the diagrams in Limberg's (Limberg 1928) article shows a sagittal sectioning or splitting of the ramus similar to the Obwegeser & Trauner procedure. Again no reference is given.

Dal Pont (Dal Pont 1961) modified the technique by using an extended lateral cut with two medial cut variations. One he called the sagittal retromolar osteotomy which differed from the Trauner/Obwegeser technique in that the medial cut was not horizontal but approximately 30° to the horizontal although still above the lingula, and that the lateral cut was now vertical and in the body of the mandible in the second premolar region. This gave a vastly increased bony contact area and consequently a faster bony union time. See diagram 24. and also demonstrated in Illustration 2.

The second variation which Dal Pont called the oblique retromolar osteotomy differed from the Trauner-Obwegeser technique in that the medial cut, while at the same angle to the horizontal as above, did not proceed to the posterior border of the ramus but stopped short just posterior to the lingula. The medial

Illustration 2 - Above: Diagrams 24 - Below

Diagram 25

sectioning then continued down almost at right angles to meet the lateral cut at the lower border of the mandible. See diagrams 24 & 25. In this latter variation the Pterygo-Masseteric sling was left on the same distal fragment which must be considered an advantage in that ramus forshortening is avoided almost completely. However as Dal Pont concedes, this technique is more difficult and the area of
bony contact is diminished compared to the original Trauner-Obwegeser technique and especially his own sagittal modification. By 1962, Obwegeser himself was using Dal Pont's modification for the extended area of bony contact that it gave. (Obwegeser 1964a).

Hunsuck (Hunsuck 1968) modified Dal Pont's latter variation (the oblique retromolar osteotomy) by not completing the medial osteotomy cut right through to the posterior border. Instead the section was allowed to proceed along as it naturally split making use of a chisel and mallet. See diagram 26. Hunsuck reasoned that as the bony architecture was very much thinner and denser posterior to the lingula and inferior to the lingula, the split will nearly always follow a natural line of cleavage that nearly corresponds to the section line that Dal Pont described. See diagram 27. Consequently there is less need for the deep and active use of burs and chisels in the mandibular canal region. However there is a concomitant increase in the use of the chisel and a greater degree of cleavage force is applied. Hence there is a part loss of control over the cleavage. Hunsuck's medial section cut was horizontal.

Booth (Booth 1976) modified the approach of the sagittal split by making his incision from the base of the coronoid process down to the mesial of the first molar along the ridge of the external oblique ridge. In distinction to the approach of Trauner-Obwegeser who made their incision higher along the anterior border of the coronoid. According to Booth, with the normal sagittal split instrumentation, there was adequate access and visualisation of the surgical site and furthermore three difficulties were minimised.
Medial osteous incision (shaded) is made through the cortical bone at the confluence of the temporal crest and ridge of the mandibular neck above the mandibular foramen.

Extension of the osteous incision is shown crossing the retromolar region and joining the vertical buccal incision.

The buccal osteous incision is depicted with buccal cortical bone removed anteriorly to the perpendicular cut to receive the buccal flange of the proximal fragment when repositioned.

Hunsuck's Cleavage Variation of the Sagittal Split Ramus Osteotomy.

From Hunsuck 1968.

Diagram 26
Osseus Architecture of the Ramus in Relation to the Hunsuck Variation of the Sagittal Split Osteotomy of the Ramus.

From Hunsuck 1968.

Diagram 27

They were: 1. The herniation of the buccal fat pad. 2. Laceration of the buccal artery as it crosses the ramus. 3. The difficulty in closing the mucosa after fixation of the fragments.

Mercier (Mercier 1973) examined 108 ascending rami, taking planimetric measurements from the second molar backwards and came to the opinion that the horizontal section must be completed to the posterior border in order to achieve satisfactory splitting. This finding is contrary to Hunsuck's. Furthermore he advised the use of fine and wide osteotomes to achieve the split which should be
performed slowly, thus nerve damage can be minimised.

The sagittal split osteotomy in its many forms would be one of the most popular mandibular procedures for the correction of mandibular deformities. It can be used with equal facility for the correction of mandibular prognathism, mandibular retrognathism, deep closed bites and open bites.

The first reports of complications did not appear until the late 1960's and in the American literature not the European literature. (White 1969; Behrman 1969). It was not until 1972 that a very good review of the complications of the sagittal split osteotomy was produced by Behrman (Behrman 1972) [and later Swanson (Swanson 1973)] which included the results of a questionnaire received from ninety surgeons of whom sixty three had experience of the technique. The complications listed in order of occurrence (greatest first):

1. Regression/relapse.
2. Haemorrhage.
3. Disturbance of the mandibular nerve.
4. Airway obstruction/oedema.
5. Fragmentation of the ramus.
6. Necrosis or sequestration.
7. Infection.
8. Disturbance to Facial nerve.

The year before Guernsey and DeChamplain (Guernsey & DeChamplain 1971) in a report that favoured continued use of the procedure, noted that there was a very high incidence of post-
operative paraesthesia and in some cases the paraesthesia was permanent (in this report, that was later than 18 months). Fracturing in an unintended way occurred in 20% of cases. The large degree of post-operative swelling leading to respiratory embarrassment was a problem in the early cases until preventive measures were undertaken (for example the use of post-operative suction drains. See Illustration 3. Also acknowledged was the potential for relapse by noting that overcorrection was required although the degree was not specified. Finally the possibility of severe haemorrhage being a surgical problem was also noted.

Morbidity of the procedure was the reason given for Hinds to not recommend the sagittal split procedure, and instead recommend the vertical sliding oblique osteotomy of the ramus for the correction of prognathism. (Hebert, Hinds & Kent 1970).

The high incidence of possible complications are no doubt what has prompted surgeons like Epker (Epker 1977), Epker and Wolford (Epker & Wolford 1980) and Munro (Munro 1980) to describe modifications that avoid as much as possible the complications already mentioned. Epker and Wolford reported the following modifications:

Firstly the vertical section of the osteotomy, lateral to the second molar, is completed through both cortical plates of the lower border (this ensures that the split will proceed correctly);

Secondly the medial section is not completed to the posterior border but just posterior and superior to the
Positive Suction Drainage.

Illustration 3
lingula (so that the medial pterygoid and masseter muscle are left attached to the proximal segment and therefore the possibility of avascular necrosis is minimised because of continued blood supply to the proximal fragment);

Thirdly because masseter and medial pterygoid are not stripped there is less excessive swelling and less excessive bleeding;

Fourthly by not stripping and retracting posteriorly to the lingula and by visualising the neurovascular bundle after beginning and before completing the split, the damage to the neurovascular bundle is decreased;

Fifthly should the split not leave the medial pterygoid attached to the proximal segment but become part of the distal segment then the stripping of the medial pterygoid is completed through the completed fracture to lessen the amount of muscle pull post-operatively as a factor in relapse;

Finally the fragments are wired together with the distal fragment having the higher hole for the wire and the proximal segment having the lower wire hole (thus when the wire is tightened the condyle is retruded into its socket) and one major cause of relapse is prevented.

Munro (Munro 1980) advocated the need for care to be exercised during surgery. This involved modified Dautry
retractors that gave wide lateral retraction and thinner medial retraction where the mandibular neurovascular bundle was. Also the use of thin chisels carefully introduced and lightly manipulated to sagitally separate the fragments carefully to produce less damage to the neurovascular bundle as it lies in the mandibular bone.

Brusati et al. (Brusati, Fiamminghi, Sesenna & Gazzotti. 1981) reported similar problems as Munro and recommended the use of a converted cement spatula as a chisel in order to overcome problems with the mandibular neurovascular bundle. The blade is advanced along the outer cortical layer by mallet, keeping in contact with the cortical bone by virtue of its flexibility and the angle of entry into the fracture. Thus by keeping to the outer cortical layer as much as possible, the neurovascular bundle can be avoided completely, as happened in 21 cases of Brusati et al. The fragments are then separated by a large chisel which is introduced only a few millimetres into the fracture. Brusati et al. reported only 1 case of permanent dysfunction and a very low incidence of temporary impairment. Out of 40 cases, 18 had an initial impairment of nerve function (45%) and of these 18, 9 cases had no dysfunction after 2 months, and 8 had no dysfunction after 15 months. The remainder was permanent. Despite these objections, the procedure would appear to still retain its popularity.

Brusati et al. even noted an incidence of 82% irreversible nerve damage reported by Niederdollmann and Dieckmann (Niederdollmann & Dieckmann 1974).

Neuner (Neuner 1976) in a review of procedures used for the correction of mandibular prognathism, recommended the use of
Neuner's Variation of the Sagittal Split Ramus Osteotomy. 1976.
Diagram 28

A modified sagittal split procedure to correct prognathism where there was:-
(a) No discrepancy in the form and size of the dental arch.
(b) Where there is an obtuse gonial angle, of approximately 140° - 150°.
(c) No lateral crossbite present.

The body of the mandible is then rotated and displaced posteriorly, and then the fragments either wired together or screwed together using A.O. lag screws. See diagram 28. The advantage of the modified procedure is the good fixation of the fragments, and that the surgeons get very little rotation of the ramus and consequently they have found that they have never required coronoidectomy. While other procedures were studied and commented on, the most important guideline in their experience was firstly to become experienced in all mandibular procedures, and secondly that the technique may need adapting for the case and not vice versa. (Neuner 1976).

Pepersack and Chausse (Pepersack & Chausse 1978) working with Obwegeser performed a study working with cases that were mainly for the correction of prognathism. Findings were essentially the same as those for Freihofer and Petrésevic (Freihofer & Petrésevic 1975) who produced a similar study for sagittal split osteotomies used for the correction of retrognathism, but with Pepersack and Chausse's figures showing slightly poorer figures for mental nerve sensibility. 58% full sensibility and 42% with less than full sensibility. None had no sensibility. All patients had had their operation at least ten years prior to the study. It is of note that since Freihofer and Petrésevic's report and before Pepersack and Chausse's report, Obwegeser according to Pepersack and Chausse, and MacIntosh (MacIntosh 1981), has not used the Dal Pont modification of the lateral cut for most cases since that time. Consequently Pepersack and Chausse made the observation that the number of mandibular nerve injuries had decreased, but no figures were
given.

Kundert and Hadjianghelou, also working from the Zurich unit of Prof. Obwegeser, examined 35 patients operated on by the unit for prognathism, retrognathism and open bite using the sagittal split procedure of the ramus. They found that condylar displacement and rotation occurred more often where screws were used for fixation of the mandible although this was also seen with circumferential wiring where this was used for fixation. There were no cases of condyle displacement or rotation in those cases that were operated on for open bite. (Kundert & Hadjianghelou 1980). It would appear that routine radiographic checking of the condyles per-operatively is required.

MacIntosh (MacIntosh 1981) reported a 13 year review of 236 patients. MacIntosh reported none of the major operative problems reported elsewhere such as profound blood loss (av. 454 cc. range 140-2000 cc.), airway obstruction, or gross loss of bone (1 case only). MacIntosh also asserts that the best method for the introduction of the chisel is at an angle sufficient to ensure that cortical bone is split off and the neurovascular bundle left intact in a manner similar to that described by Brusati et al. However immediate Mandibular nerve dysfunction was 85% which was reported to decline to 9% after a 1 year period. Those patients with the longest dysfunction times of the Mandibular nerve, were in the oldest age group (greater than 40 years of age. Those with the longest healing time of their fractures were also in the same age group. The overall relapse rate was 30% which was significant in 12% of patients. MacIntosh reported that the worst relapses were noted in patients who presented for the correction of apertognathia. This
prompted MacIntosh to comment that in his opinion the sagittal split osteotomy was not suitable for treating cases of apertognathism. Condylar seating and fixation were two areas where MacIntosh considered serious difficulties could arise. MacIntosh noted that Freihofer (Freihofer 1976) recommended the use of operative radiographs and considered the idea sound, but he also recommended that a gentle but firm seating pressure of the condyle was best suited to those operators who do not have the convenience of operative radiographs available. Macintosh recommended the use of circummandibular wiring to stabilise fragments, often using two wires per side. He did not recommend the use of per-alveolar wiring as this could produce distraction of the condyle from the fossa. The circumferential wiring allows freer adaptation of the condyle into its fossa especially when subjected to post-operative movement from muscle re-attachment and wire stretching.

Simpson (Simpson 1974) did a similar post-operative review of his and others' patients comparing the sagittal split procedure to the subcondylar osteotomy and noted that while both procedures were satisfactory, the sagittal split osteotomy had the highest number of post-operative complications. In particular nerve damage to the mandibular nerve was highest in the sagittal procedure 20% of patients as against 12% for the subcondylar procedure. Relapse was the same for both (44%) and none were considered marked relapse.

**Development of the Vertical Ramus Procedures.**

Essentially American in concept and development, this procedure does take its roots from early European surgery.
About 3 years after Kostecka reported his oblique horizontal ramus procedure for the correction of prognathism (Kostecka 1928), he reported a technique for the correction of prognathism based on a procedure or series of procedures developed by Limberg (Limberg 1925) for the correction of open bite deformities. (Kostecka 1931). See diagram 29.

Kostecka's approach was similar to the blind approach of Blair in that the incision was external and an aneurysm needle was used. See diagram 30. Kostecka described two incisions, one made about 3 centimetres above the angle of the mandible and immediately posterior to the posterior border of the ramus, and the other incision directly over the lowest point of the curve of the sigmoid notch. An introducer was passed down the first incision which had been extended by blunt dissection to the posterior border

Diagram 30
Kostecka's Subcondylar Osteotomy and Approach (Cont.)
After Kostecka 1931.

Diagram 30

of the ramus and then passed medially to the ramus and up at an oblique angle and forward to exit through the second incision between the coronoid process and the condyle. The Gigli saw was passed through and with suitable protection of the soft tissue, the neck of the condyle was sectioned at an oblique angle. The procedure was repeated on the other side. The mandible was then placed into its corrected position. Kostecka's indications for the procedure were open bites and prognathism, especially in combination.

Schaefer (Schaefer 1941) and Reiter (Reiter 1951) both reported very satisfactory success rates for the operation. All three authors used the blind approach described by Kostecka, but used an increased angulation of bony section tending more towards the vertical.
Weiss, Lentz and Newman (Weiss et al 1941) and Henry (Henry 1946) also gave very good reports on the success rate in their use of the procedure. This despite a reported case of non-union from Weiss et al.

Verne, Polachek and Shapiro further modified Kostecka’s procedure to the point where the posterior border cut was just posterior to the angle. The bony section was now more vertical compared to Kostecka’s cut which was much nearer to the horizontal. See diagram 31. This new cut was part of a trend towards vertical and oblique vertical osteotomies of the ramus, away from the horizontal osteotomies of the ramus. Unlike most of the developing vertical style ramus procedures, this series of operations still used the blind approach after Kostecka. Verne et al had their post-operative results evaluated over a 10 year period, the first operations being performed in the late 1940's. Verne et al found the

A. Kostecka's Osteotomy of the Condylar Neck
B. Verne, Polachek and Shapiro's Osteotomy of the Condylar Neck.

After Kostecka 1931. After Verne, Polachek and Shapiro 1957.

Diagram 31
operation to be effective, uncomplicated and relatively atraumatic. (Verne, Polachek & Shapiro 1957).

A series of new names began to appear for these newer vertical operations on the ramus. Subcondylar osteotomy (Hinds 1958); vertical subcondylotomy (Robinson 1958); overlapping vertical osteotomy (Robinson 1959); oblique osteotomy (Limberg 1925, Thoma 1961); vertical subcondylar osteotomy (Hebert, Kent & Hinds 1970); oblique sliding osteotomy (Shira 1961, Robinson 1970); and vertical oblique osteotomy (Nordenram & Waller 1968). See diagrams 32. The author has also heard of the term vertical subsigmoid used for such operations but used mainly where the cut is anterior to the angle of the mandible.

The procedures mentioned above have a number of points in common. The sectioning of the bone in these operations commences from the lowest point of the curvature of the sub-sigmoid notch and extends down to a point ending either just anterior, just
posterior or at the angle of the mandible. See diagram 33. All employ the technique of overlapping the posterior fragment lateral to the anterior fragment. Thus the lingula and consequently the inferior dental neurovascular bundle is avoided. The overlapping technique, and the procedure in general, is best suited for the correction of prognathism. Mostly there is a requirement to remove a wedge of bone in the sub-sigmoid area to allow a more satisfactory overlap of the fragments.

Hinds and Kent suggested modifications to the basic procedure that included recommending that where the amount of retrusion was greater than 15 mm, then removal of a subsigmoid wedge of bone was desirable or alternatively a vertical strip of bone from the proximal segment, and then butting the fragments. Other modifications included sectioning of the coronoid process (discussed


Diagram 34

Blair's Posterior Border Approach. 1915.

Diagram 35

Hinds (Hinds 1957, 1958) was an advocate of the procedure using either the posterior border approach of Blair (Blair 1915), see diagram 35; or the submandibular approach, of Risdon (Risdon 1934). See diagram 36 and demonstrated in Illustration 4. Risdon described this approach for the treatment of disorders of the submandibular gland. Access to the gland was gained without severing the lowest (cervical) branch of the Facial nerve, and producing minimum scarring to the face by making use of the natural skin folds of the neck. The incision was 1½ to 2 centimetres below the lower border of the mandible and the approach made by a combination of blunt and sharp dissection subcutaneously, through a layer of fatty tissue and then platysma. The submandibular gland was then attained by blunt dissection from that level to the gland deep to the mandible but inferior to it. The procedure was adapted for access to the
Risdon's Submandibular Incision. 1934.

Diagram 36

Ramus by locating and dividing the facial vein and artery, and then proceeding with sharp dissection through masseter to the ramus/angle region. Masseter and medial pterygoid muscle were stripped from their attachments and special instrumentation provided good access to the lateral border of the ramus, or the lower border where desired. The procedure is quite adaptable for any procedure requiring access to the lower border of the mandible. (After Risdon 1934).

This approach became more popular than Kostecka's approach as the problems of Kostecka's blind approach, such as malunion and pseudoarthrosis, became better understood (Caldwell & Letterman 1954). Alling (Alling 1965); Georgiade and Quinn (Georgiade & Quinn 1961), Hinds (Hinds 1957, 1958), Hinds et al (Hinds, Galbreath & Sills 1962, Hinds & Girotti 1967), Nordenram and
Submandibular Incision After Risdon.

Illustration 4
Waller (Nordenram & Waller 1968), Robinson (Robinson 1959, 1970), Shira (Shira 1961) and Thoma (Thoma 1958, 1961) all reported using this approach.

Moose, with his previous development of intra-oral instrumentation for performing the horizontal osteotomy intra-orally and from the medial aspect of ramus (Moose 1945), devised and performed an intra-oral approach for the vertical oblique sliding osteotomy undertaken from the medial aspect of the ramus, (Moose 1964). This report, unlike his first, did not recommend that this procedure be performed routinely. The basic disadvantage was that the medial aspect of the ramus was very difficult to visualise and in a practical sense constituted a blind approach due to the lateral curvature of the ramus. Hebert, Kent & Hinds repeated the procedure in 1970 and came to the same conclusion. The only two advantages were the lack of scarring which was significant in people prone to keloid formation; and the avoidance of the Facial nerve. The lack of visibility from the medial aspect was especially a disadvantage when there was a haemorrhage problem and the source of the bleeding could not be visualised. (Hebert, Hinds, & Kent 1970). Massey et al claimed to have solved lack of visibility by making use of special instrumentation that allowed both good access and visibility for the medial intra-oral approach for the vertical oblique sliding osteotomy. Massey et al reported a very low incidence of mandibular nerve damage using their instrumentation and technique. (Massey, Chase, Thomas & Kohn 1974). However the technique is not often reported, the majority of cases reported preferring the extra-oral approach or the lateral intra-oral approach for this procedure.

Winstanley made use of special instrumentation to
Caldwell and Letterman's Vertical Ramus Osteotomy. 1954.

Diagram 37

perform the vertical oblique sliding osteotomy, via an intra-oral lateral approach. While being easier than Moose's intra-oral medial approach, it was not without its difficulties as reported by Winstanley, such as sufficient access, poor visibility to the area and protection of the Mandibular Neurovascular bundle superior to the lingula. (Winstanley 1968).

At about the time that Limberg's and Kostecka's oblique subsigmoid procedure was being developed into a more vertical cut by dropping the posterior border end-cut more inferiorly
towards the angle; a totally new technique was being developed by two Americans for the treatment of prognathism. Caldwell and Letterman (Caldwell & Letterman 1954) described an extra-oral technique using a modified Risdon approach that greatly avoided the problems (relatively small that they were at that stage of development) of a lack of bony union. See diagram 37. The initial cut was similar to Kostecka’s procedure in that it started at the lowest curve of the sigmoid notch. The section then continued inferiorly, vertically, to pass posterior to the lingula and finished anterior to the angle. The lingula can be detected laterally by a small rounded prominence. The reliability of this will be discussed later. The procedure had several advantages. Firstly the potential for damage to the neurovascular bundle is much decreased over other ramus procedures especially the sagittal split osteotomy. Secondly the retention of a definite angle.

The coronoid process was detached from the ramus but not stripped of its muscle attachment (the Temporalis). This allowed the coronoid process to remain in close proximity to the ramus and encourage re-attachment to the ramus. At the same time the coronoid was tilted anteriorly relative to the ramus as the ramus was retruded. This way post-operative impingement of the coronoid with the zygomatic arch was avoided and thereby maintaining the range of function of the mandible. There was at the same time a decreased risk of ankylosis of the coronoid process to the zygoma. Such a complication was reported by Troyer when the vertical cut was taken a little further anteriorly than normal to include the coronoid process. The coronoid process had not been sectioned, and became ankylosed to the zygoma. (Troyer 1971). As well as ankylosis, the superior pull of Temporalis, a factor in relapse especially where the

Diagram 38

procedure is used for the correction of retrognathism, was avoided. If Caldwell and Letterman had proceeded no further they would have contributed significantly. As it was they proceeded to decorticate the anterior portion of the mandible and drill holes through (and through) the posterior portion of the mandible (medial decortication being impractical). The posterior fragment was then placed over the anterior fragment before the occlusion was fixed in the new position. Caldwell and Letterman maintained that this had several advantages. Firstly there was no bulky overriding of the fragments laterally, and secondly there was a vastly decreased healing time. The fragments were wired at the lower border both vertically and horizontally (anterior and posterior to the angle).

This procedure is reputed to have the fastest healing time of all the ramus and body procedures. (Hinds & Kent 1972). Union has been known to take place in three weeks and 4 to 5 weeks is usual.
Robinson (Robinson 1956) adapted Caldwell and Letterman's procedure by performing the same approach and same sectioning without the decortication also for the correction of prognathism. Robinson commenced using this variation in 1954 and wrote a preliminary report in 1956 on his five cases. In 1958 he examined the procedure after forty three cases were operated on. (Robinson 1958). Robinson felt that overcorrection should be attempted in all cases to produce both a small degree of retrognathism and of posterior open bite. See diagram 38.

Georgiade and Quinn (Georgiade & Quinn 1961) further modified the procedure of Robinson's by making his section oblique in the inferior – superior plane, thus allowing easier sliding of the fragments as the anterior fragment is moved posteriorly to correct prognathism. The oblique or tangential section also gave the bone cuts a greater area of contact and also a greater degree of stability. Osseous wires were still required to be placed. See diagram 39.

Caldwell and Hughes (Caldwell & Hughes 1958) particularly recommended this procedure for edentulous and partly edentulous patients, using Gunning splints for fixation.

The procedure of Caldwell and Letterman's can be modified by not performing the decortication and treating the section cut as a vertical sliding osteotomy. See diagram 40. Most of the modifications developed that are based on the Caldwell and Letterman procedure have been used in the treatment of other mandibular deformities.
The osteotomy site and tangential saw cut is shown which is distal to the mandibular nerve and vessels. A, the cortex underlying the newly positioned distal ramus fragment is removed with a bone bar. C, positioning of the fragments is shown after excess bone removal.


Diagram 39

Knowles et al (Knowles, Kernahan & Burston 1963) were of the opinion that although they favoured the use of the ramus for the correction of prognathism, this area of surgery had certain disadvantages namely:

1. Malunion or non-union is possible
2. Anterior open bite is more likely with ramus operations in general
3. Anaesthesia of the Mandibular nerve still occurs which can be either temporary or permanent
4. Often a neuralgia of the Mandibular nerve distribution occurs which is distressing for patients
5. Relapse does occur
Oblique osteotomy for prognathism. The posterior condylar fragment is allowed to override the anterior coronoid fragments.

Vertical osteotomy of the ramus of the mandible by the external approach. A. The line of osteotomy of the ramus of the mandible. The perosteum is raised from both the medial and lateral aspects of the ramus. B. The osteotomy is completed and the posterior fragment is placed laterally over the lateral aspect of the ramus of the mandible, where it is maintained in bony contact by the pull of the lateral pterygoid muscle. C. Excess bone on the inferior margin of the posterior fragment is beveled with the bone cutter.

The Vertical Sliding Subsigmoid Osteotomy of the Ramus. From Hinds & Kent 1972.

Diagram 40

6. Haemorrhage can be difficult to control
7. Excessive post-operative proclination of the incisors can occur

Knowles et al made use of precision cut template
made of metal and based on mainly radiographic and also model prognosis studies to help guide the section cuts and determine the amount of bone that should be removed. Thus helping to avoid many of the above disadvantages.

Nordenram (Nordenram 1968) reviewed some of the procedures available for the correction of prognathism. The procedures were:
1. The horizontal osteotomy of the ramus.
2. The vertical oblique (vertical subsigmoid) osteotomy of the ramus.
3. The vertical body ostectomy.

Nordenram recommended that prognathism be corrected through the ramus and therefore did not completely review the body procedures. Of the two ramus procedures, the vertical oblique osteotomy was preferred.

The horizontal osteotomy was found to have the following advantages:
   a. Simple operation technique, except where osseous wiring is placed.
   b. Short operation time.

and the following disadvantages:
   a. High degree of relapse, due to unfavourable muscle pull.
   b. High incidence of damage to the mandibular nerve.
   c. Insufficient bony contact that increased healing time and often produced non-union.
   d. High incidence of post-operative root resorption.
The vertical oblique osteotomy was found to have the following advantages:

a. A greater degree of bony contact.
b. More favourable muscle pull, and a much lesser degree of relapse.
c. A shorter healing and fixation time compared to the horizontal osteotomy. (Six weeks as opposed to ten weeks for the horizontal procedure.)
d. A reduction in the incidence of mandibular nerve damage.
e. Despite Alling's (Alling 1965) report of three to five hours for the procedure, Nordenram found the procedure to be quick and simple, with the average operating time of fifty-five minutes.
f. The general complication rate was lower due in part to the good access afforded by the Risdon approach.

Relative to the horizontal ramus osteotomy, there were no disadvantages to the vertical procedure.

Astrand et al (Astrand, Bergljung & Nord 1973) examined fifty-five patients who had a vertical oblique sliding osteotomy performed through an extra-oral approach. Short term studies showed a remarkably low complication rate. One case of damage to the Facial nerve, two cases of damage (temporary) to the Mandibular nerve, and seven patients with Temporomandibular Joint Dysfunction. They recommended a 19% (average) overcorrection to allow for relapse which they considered to be the greatest (but not a major) disadvantage of the Vertical Subsigmoid procedure.

There are anatomical landmarks to help visualise
the location of the lingula from the lateral surface which help to account for the low incidence of damage to the mandibular nerve as reported above. The best known is the anti-lingula, which is a protrusion of bone on the lateral aspect of the mandible over the lingula and hence a guide for placing the vertical section when performed and visualised from the external approach. However the accuracy of this protrusion has been questioned. Yates et al. (Yates, Olson & Guralnick 1976) in a study of 70 mandibles (140 rami) noted that there was a definite antiligula present in less than half of the rami studied (44%), and an indefinite lingula present in slightly fewer (41%). There was no detectable antiligula in 15% of the rami studied. Where the lingula was definitely noted, the deepest point of the lingula was usually (80% of cases) in the quadrant posterior and inferior to the highest point of the lingula. In 37.1% of rami the lingula was within 5mm. of the antiligula, and within 10 mm. of the antiligula in 72.6% of rami. A section cut therefore, made greater than 10 mm. from the antiligula when the antiligula is definitely noted is safe for only three quarters of bony cuts made. A useful, but certainly not reliable landmark as the antiligula is either indefinite or absent in over half the rami examined (56%). (Yates, Olson & Guralnick 1976). Reitzik et al in a similar statistical anatomical study recommended that the "Masseteric Apical Bump" (the antiligula) be ignored and reference taken from the maximum constriction (the waist) of the ramus rather as a point of reference on the lateral surface for the lingula. The waist of the ramus was usually above the level of the lingula by a satisfactory margin. (Reitzik, Griffiths & Mirels 1976).

Astrand and Ridell (Astrand & Ridell 1973) when reviewing the problems of post-operative relapse expanded further on
relapse noted above (Astrand, Bergljung & Nord 1973). They found that although there were changes in the mandible the degree of relapse was acceptable. The greatest area of change was in the ramus with forshortening of the ramus and therefore there was a superior movement of the angle of the mandible and a consequent shortening of the posterior facial height. There was a much smaller amount of relapse of the chin point (retruding) but again the result was quite acceptable. There was very little change to the anterior facial height.

Wang and Waite (Wang & Waite 1975) compared the sagittal split osteotomy of the ramus with the vertical oblique sliding osteotomy of the ramus (performed extra-orally) and found that there was little difference between the two procedures in the long term, provided due and proper care is taken during the procedures. This would seem to be contrary to the general trend in the literature which appears to show a greater number of articles noting the disadvantages and complications of the sagittal split procedure when compared to the vertical oblique sliding osteotomy.

Robinson (Robinson 1977) also using the extra-oral approach advised empirically that a 20% overcorrection be performed to allow for relapse.

Shepherd (Shepherd 1980) performed a good long term (minimum five years) review of ramus stability comparing the vertical oblique sliding osteotomy with, and without a coronoidectomy, and the sagittal splitting ramus procedure. The vertical oblique procedures were all performed using an extra-oral approach. In nineteen patients using the sagittal split procedure no significant resorption
of the ramus was noted except in one case where the third molars were removed at the time of the surgery. In thirty patients using the vertical oblique sliding procedure, eleven patients had obvious resorption with the width of the ramus being significantly narrower, and three patients had gross resorption producing a "waisting" effect of the ramus not unlike an hourglass. Most of the resorption on average appeared to take place in the first six months some cases showing a slight increase in width after that time. Shepherd attributed this resorption of the ramus to partial loss of blood supply due to masseter stripping. As Medial Pterygoid remained attached avascular necrosis did not occur. Shepherd conjectured that the ramus in such patients may be at greater risk of fracture that the normal width ramus. Where a coronoidectomy was performed without detachment of the Temporalis, the coronoid displaced superiorly. After 5 years new formation of the coronoid was noted. Whether this was due to the growth of a new process or the re-attachment of the old process is not clear. The latter is favoured as in some cases the old cut lines could be noted. In two cases (out of thirteen where a coronoidectomy was performed) there was no new process and the coronoid remained unattached.

Greebe and Tuinzing took the opportunity to emphasise a new trend away from the extra-oral approach. They noted that their series of thirty-five patients treated for prognathism using the vertical oblique sliding procedure, via an oral approach, did not require any over-correction. They attributed this to the relative lack of disturbance of the mandibular musculature through the use of the newer instrumentation (especially designed tunnel retractors and angled oscillating saws), sectioning the coronoid process routinely, and establishing good interdigitiation. (Greebe &
Tuinzing 1982). This is a trend (the oral approach) that may well be noted more often in the literature in future. The findings of Shepherd will probably influence other surgeons to further examine the indicated advantages of the oral approach over the extra-oral approach for the vertical oblique sliding procedure.

There are therefore a number of disadvantages to the extra-oral approach. Facial nerve can be damaged permanently if the approach is careless and damaged transiently if retraction is too hard. The operating time is long if decortication is performed, but is quite short if the simpler sectioning version more commonly favoured is carried out. Decortication is not necessary unless rapid union is required. Post-operative airway obstruction as a result of operating on the neck must be taken into consideration (that is, the use of a tracheostomy must be considered in selected cases, and the need for suction drainage post-operatively.). There is some external scarring but good technique should minimise that, and it is not usually a major problem with any external neck approach.

The popularity of the procedure testifies to the number of advantages most of which have already been discussed but will be summarised below. It is particularly useful in cases of moderate to severe prognathism. (Greater than 10 millimetres.). Three to five weeks for clinical union is usually all that is required on average. There is therefore less chance for extrusion of splinted teeth from extended intermaxillary fixation time, and furthermore simple intermaxillary fixation will suffice. There is little Temporomandibular joint stress post-operatively if simple precautions are taken such as ensuring that the condyle is pushed up into the fossa and that the fragments are not wired together.
tightly. There is relatively little incidence of mandibular nerve
damage, and what damage there is, is temporary. Vertical stability
is high as the fragments are not greatly influenced by either Medial
Pterygoid or Masseter. The tendency for open bite is very much
diminished as a corollary of the rapid healing and the minimal
disturbance to the Pterygo-masseteric muscle sling.

Where the prognathism is severe (Souyris 1978) and
accompanied by retrusion of the maxilla to further compound the
problem (Lindorf & Steinhäuser 1978), Souyris and Lindorf &
Steinhäuser recommended that bone plating be the primary form of
fixation, with intermaxillary fixation providing a secondary
fixation. For moderate to severe prognathism Souyris recommended the
Sagittal Split procedure. For severe prognathism with accompanying
maxillary retrusion, Lindorf & Steinhäuser recommended that the
vertical sliding osteotomy be performed so that the correct
predetermined amount of retrusion can be obtained with more visual
accuracy and the mandible fixed independent of the maxilla. Thus
when the maxilla is operated on and freed, there is still a basis for
locating the maxilla into its new predetermined position due to the
firmly and independently secured mandible.

Most reports do simplify the use of procedures even
where the problem is severe. Where the problem is severe, these
reports prefer to make use of simple procedures done in separate
stages, or a single complicated procedure done in one stage. Until
recently surgeons preferred not to perform many simultaneous
procedures especially on more than one bone, adding to the overall
complication of the surgery. Such simultaneous procedures not only
included soft tissue procedures for the resiting of muscles, such as
the Pterygo-masseteric sling or the hyoid group of muscles, but also multiple bony procedures to reposition more than one bone or fragment of bone. Coronoidotomy as an adjunct procedure to the vertical sub-sigmoid procedure is an example of this. In such extreme cases, then a single surgical procedure does not achieve a satisfactory result. However there is a recent tendency seen in the literature for multiple simultaneous procedures to be performed. Caldwell (Caldwell 1968) was one of the first to report the use of multiple simultaneous procedures for the correction of an extreme prognathic problem. He performed a simultaneous coronoidotomy, vertical sub-sigmoid osteotomy, sub-sigmoid wedge ostectomy, and Medial Ptérygoid and Masseter muscle resiting.

Not only extreme deformities but also deformities that are present in more than one area are best treated by several procedures. Again there is a tendency as shown by both Bell et al. (Bell, Proffit & White 1980) and Epker (Epker & Wolford 1980) in their textbooks, to treat the problems simultaneously by multiple procedures.

Summary

General indications for the treatment of prognathism were outlined by Horowitz et al (Horowitz, Converse & Gerstman 1969) as 1. Facial disfigurement in which the lower portion of the face is unduly prominent.

2. The presence of a Class III (Angle) malocclusion of the teeth.

Hinds and Kent (Hinds & Kent 1972) listed general indication for the treatment of prognathism as (a) occlusal
interferences, (b) masticatory and digestive upsets, (c) periodontal disease, (d) poor oral health, (e) poor speech, (f) unsatisfactory denture construction, (g) unsightly appearance, (h) Temporomandibular joint dysfunction.

Most of the reported cases for the correction of mandibular prognathism in the last thirty years have been through the use of ramus procedures, the literature being divided into those for the sagittal split procedures and variations, and those for the vertical ramus procedures and variations. While there has been a recent (1982) revival in the use of body procedures for the correction of prognathism, the bulk of current literature favours the use of ramus procedures. Indications in general are based on the understanding that the ramus or angle portion of the mandible is the main area of the deformity and not the body of the mandible. Also any pre-surgical deformity or post-surgical discrepancy is often able to be corrected by use of orthodontics to realign the occlusion. Furthermore the main advantages of the ramus procedures over the body procedures are that the ramus procedures do not require the removal of teeth, there is no shortening of the dental arch form; in some procedures a small but significant margin of safety in preservation of the Mandibular neurovascular bundle, and in other ramus procedures, a large margin of safety for the neurovascular bundle.

As well there were the disadvantages of the body procedure such as problems of non-union, removal of teeth to achieve the removal of the required amount of bone, and the mismatching of the anterior and posterior segments when butted together. These were the major problems.
There is still much controversy regarding the advantages and disadvantages of the different types of procedures for the correction of prognathism. The controversy mainly centres about the sagittal split procedures and the vertical ramus procedures. There has already been detailed discussion on the advantages and disadvantages of both and there is no point in repeating them. The single most important argument is the higher risk of damage to the mandibular neurovascular bundle that the sagittal split procedures have compared to the vertical sub-sigmoid procedures. There are regular reports on techniques and instrumentation designed to decrease the risk. It would appear however that proponents of both procedures will probably remain convinced that their procedure is the better indicated for the correction of prognathism.

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MANDIBULAR PROGNATHISM

Body Procedures

Introduction.

The treatment of prognathism has undergone a series of in and out of vogue procedures, commencing initially with a vertical body section, which took place in the late 1800's, to develop into step osteotomies of the body, at the same time that ramsus procedures were being developed for correction of prognathism. Gradually ramsus procedures became more popular, with body procedures being only occasionally reported in the 1960's.

A point of major contention in the development of the body procedures has been the importance of the mandibular neurovascular bundle. Initially surgeons did not concern themselves with the problem, but gradually there were attempts to preserve the integrity and function of the nerve. Some reports showed that there was not much difference in the time interval from sectioning to the return of nerve function regardless whether the nerve was sectioned or not. This particular problem is probably the main reason why there has been a gradual return to the use of body procedures for the correction of some mandibular deformities.

There has been a slow resurgence of reports on body procedures as the complications, difficulties and not entirely satisfactory results of ramsus procedures have made some surgeons return to body procedures, the step osteotomies in particular. This has also been demonstrated by the development of alveolar procedures to achieve results not possible with either gross body procedures nor
Diagram 41

Blair's Body Osteotomy for the Correction of Prognathism. From Blair 1909.

gross ramus procedures. The alveolar procedures are not part of this chapter and will be dealt with in the chapter on Alveolar Procedures.

Discussion.

Development of Vertical Body Procedures.

The earliest recorded body procedure for the correction of prognathism alone was by Blair in 1897 and reported by Whipple, whose patient it was, (Whipple 1898) and Angle (Angle 1903) and later by Blair himself (Blair 1907). Hullihen (Hullihen 1849) had performed the first body osteotomy but the procedure was for the correction of an open bite deformity principally, and was not a full thickness osteotomy but more of a subapical type of osteotomy.

Blair performed the first full thickness body
osteotomy for the correction of an extremely prognathic mandible at the behest of Angle (Angle 1903). See diagram 41. The patient was a medical student who had presented to Angle, who in turn referred him to Blair for surgical treatment as Angle felt that the problem was beyond the scope of Orthodontics. It was Angle's opinion that moderate to extreme mandibular prognathism was best treated by surgery alone as tooth movement alone was insufficient.

Blair's procedure was initially a one stage operation. The procedure was subsequently broken down into two stages. The first stage was the removal of the two first molars some weeks earlier to allow for healing of the socket sites. This was performed under local anaesthetic. The second stage was under a general anaesthetic. An incision was made at the level of the lower border of the mandible on the skin, directly under the area of bone to be removed. A parallelogram of bone was removed from each site by a flat saw in the original case and by a Gigli saw in the subsequent cases. The mandible was retruded by the amount of bone that was removed. The perioseum was dissected in such a manner that there was no oral compounding of the wound. This was important in the days before antibiotics. The Gigli saw used later allowed Blair to preserve the oral mucosa from tearing which was more difficult to achieve with the flat saw.

Blair's first case was fixed with a sub-mental plaster support and by interosseous wires. Subsequent cases were a mixture of cast sectional splints, see diagram 42, and/or orthodontic bands in combination with interdental (not eyelet) wiring. All cases had a lower border interosseous wire placed. The latter despite post-operative complications and criticism by Angle as being
Fixation as Used by Blair. From Blair 1909.

Diagram 42
unscientific. An opinion put forward by others since (Limberg 1928, Smith & Johnson 1940). Angle suggested the use of a metal template to ensure that only the proper amount of bone was removed so that better occlusion could be attained. Angle was most dissatisfied with the result from the viewpoint of occlusion.

Blair (Blair 1915) advocated the philosophy that the primary consideration of facial surgery was the correction of facial aesthetics first with consideration of the occlusion secondarily. This philosophy has been emphasised by others including Obwegeser (Obwegeser 1973), but disagreed with by still other authors (Angle 1903). It was Blair's understanding that the problems of mandibular prognathism lay in the body of the mandible and therefore this was where the area of correction should be. As well, Blair was of the opinion that correction of retrusion of the mandible surgically through a body procedure would lead to a decreased function of the mandible and hence surgery in this area for the correction of retrognathism was contra-indicated. This has subsequently been shown not to be so.

In 1904 Lane (Lane 1906) performed a similar ostectomy in the premolar region of the mandible, that is the removal of a parallelogram of bone, for the correction of pseudo-prognathism resulting from a cleft palate.

Pickerill (Pickerill 1912) and Pichler (Pichler 1918) reported similar cases to Blair's body ostectomy for the correction of prognathism. Pickerill tried to avoid damage to the mandibular neurovascular bundle but did not succeed. Pickerill performed the surgery firstly on one side, removing the tooth and
then performing an extra-oral lower border approach to excise the required segment of bone. The cut ends were butted together and held by a cast cap splint. As the wound became infected, the surgery for the opposite side was deferred for two months. At that stage the second side was operated in a like manner as the first, and the first side reopened to allow a lower border wire to be placed. A second cap splint was placed over the entire lower arch.

Willett (Willett 1927), Henschen and Schwarz (Henschen & Schwarz 1928), Kazanjian (Kazanjian 1932) and Padgett (Padgett 1938) also performed their (similar) body osteotomies in the canine region. Kazanjian had performed five cases by 1932 and eight by 1936 (Kazanjian 1936).

Ballin was the first to perform a two stage procedure that Blair later adopted. (Ballin 1908; Blair 1909). The teeth were extracted prior to the osteotomy in order that the operation not be contaminated orally. It was after the extraction sites had healed that the major procedure was undertaken. This is now the preferred approach to body osteotomies by authors as late as 1968. (Hovell 1956; Rowe 1960; Converse, Horowitz and Wood-Smith 1968).

Aller (Aller 1917) and Ernst (Ernst 1927) devised a one stage transmucosal intra-oral approach in an attempt to avoid facial scarring. The surgery was performed via a three sided free gingival flap. Converse (Converse & Shapiro 1952) devised a reverse flap that was based on the attached gingiva and called for careful dissection of the mental nerve. See diagram 43. Converse recommended this intra-oral approach for the young and for females

Diagram 43

where external scarring should be avoided. The neurovascular bundle, once identified and dissected free from the soft tissue, was then dissected free from its bony canal. Converse performed his sectioning in the premolar region.

In the early stages of the development of body osteotomy techniques there was little attempt to preserve the neurovascular bundle but gradually this aspect of the techniques became a subject of contention that could not be ignored. Surgeons were attempting and succeeding in protecting the neurovascular bundle. Gradually more and more procedures were reported that protected the neurovascular bundle. Some authors were contending that there was little difference between the sectioning of the bundle and the manipulation that the bundle received when not sectioned. Johnson and Jakubs (Johnson & Jakubs 1956) demonstrated this by
showing and comparing what happened when one side was cut and the other side was left intact. Sensation returned in ten months in the intact bundle, and in thirteen months in the cut bundle.
Preservation of the neurovascular bundle was first attempted by Harsha (Harsha 1912). See diagram 44. Harsha made an external incision approximately 2½ inches long along the lower border of the mandible. The rhomboid section was removed by using bone cutting forceps and bone nibbling forceps (rongeurs). The neurovascular bundle was isolated and pulled out of the way by means of silk thread. The two fragments were then approximated and wired together. The bundle was left protruding from the butted sections of bone. Any teeth that were required to be removed were done prior to the operation to decrease any chance of operative infection. Little was made of this report until 1941 when New and Erich (New & Erich 1941) strongly emphasised the need for preserving the bundle. There can be little doubt of the need to preserve the bundle when it can be noted that nearly all the procedures that require sectioning of the bundle have died out. It is because of this need to preserve the bundle that much has been written regarding techniques that do keep the bundle. (Nordenram 1968; Astrand et al 1973). This subject was reviewed by Massey et al. (Massey et al. 1974) and there has been a study on the subjective appreciation of neurovascular damage in which patients gave their views (Simpson 1974), to name just a few articles written on the need to preserve the neurovascular bundle. Simpson noted that the patient's concern was quite significant in the patient's assessment of a satisfactory result.

Following New and Erich's report there were several articles on techniques that stressed the need for preservation of the neurovascular bundle. For example Thoma (Thoma 1943) and Dingman (1944a, 1944b, 1944c, 1948). Thoma's procedure has already been mentioned.
Dingman's Two Stage Body Osteotomy.
From Dingman 1944c.

Diagram 45

Development of the Step Body Procedures.

Dingman's procedure (1944c) was a two-stage intra-oral removal of teeth and the first of the bony sections. This stage was performed under local anaesthetic. With the teeth removed the mandible was exposed down to the level of the mental foramen and two vertical sections were made just posterior to the foramen, the distance between the vertical cuts determined by the amount of set-back required of the anterior fragment. The second stage four weeks later, under a general anaesthetic, was via an extra-oral lower border incision to complete the remainder of the section cuts and remove the necessary bone and retrace the anterior part of the mandible. The neurovascular bundle, once identified coming from the foramen, was dissected free coming from its bony canal and replaced.
at the end of the procedure into a small compartment cut into one or both of the fragments. The compartmentalising of the bundle was essentially part of any procedure that attempted to preserve the neurovascular bundle in a body procedure. (See diagram 45).

Dingman was of the opinion that the two stage procedure was the only way to avoid the complications of oral-based infections.

It was this procedure that first Thoma (Thoma 1948) then Burch, Bowden and Woodward (Burch, Bowden & Woodward 1961) and later Huebsch (Huebsch 1954) devised a one stage approach for; Burch et al. via an extra-oral approach, and Thoma and the others by an intra-oral approach. Burch et al, Thoma and Huebsch all performed virtually the same bony procedure

It is of note that as late as 1966 Archer was still recommending the use of a Gigli saw for the removal of the bone in the correction of mandibular prognathism. The procedure was very similar to Blair's (Blair 1907) procedure. No attempt was made to preserve the neurovascular bundle, Archer considering this to be unnecessary. Evidently the need to preserve the integrity of the neurovascular bundle was still in dispute. Archer stated that in all cases there was regeneration of the neurovascular bundle within one year on average. (Archer 1966).

Scougal and Colvin (Scougal & Colvin 1951) using Dingman's technique for the correction of a prognathic mandible, recommended the use of a Kirschner wire for the stability of the fragments after osteotomy in the case of edentulous or nearly
Dingman's Two Stage Step Body Osteotomy.
From Dingman 1948.

Diagram 46

edentulous patients. It was noted that the wire often damaged the neurovascular bundle but no permanent effects were noted. This despite the difficulty of stabilising the fragments during the insertion and the instability of the fragments against rotating forces.

Pichler (Pichler 1918) was the first to report a step osteotomy for the correction of prognathism when he also reported at the same time a vertical section procedure after Blair (Blair 1907) previously mentioned. The step osteotomy was entirely extra-oral (direct approach over the lower border of the mandible). Dingman (Dingman 1948) was the first to report a step osteotomy for the correction of prognathism which avoided sectioning the mandibular neurovascular bundle. See diagram 46. An advance on his previous
Converse's Step Body Osteotomy for Correction of Prognathism. From Converse 1951.

Diagram 47
two stage vertical section osteotomy of the body to correct prognathism. Both Dingman's procedure and Pichler's procedure were performed in the premolar region.

There had been previous reports of step osteotomies for the correction of various deformities of the mandible and most were for the correction of retrognathism. Hence the development of these step procedures will be discussed in the chapter on Retrognathism (body procedures).

However some discussion is relevant at this point. The step section had several advantages over the simple section osteotomy of the body, of which there are many variations. Most of the advantages were related to the application of the osteotomy for the correction of retrognathism, but the principle advantages of the step was to increase stability of the fragments by stopping the tendency of the proximal fragment to displace itself, and to produce a much greater area of bony contact and thus to increase the chances of bony union.

Converse (Converse 1950) followed Dingman's report with a report on the development of the step osteotomy. Converse used the step cuts of Dingman (Dingman 1948) but through an entirely oral approach and hence a one stage procedure step osteotomy. See diagram 47. Converse recommended this intra-oral approach for the young and for females (to avoid external scarring). The neurovascular bundle is identified, dissected free from the soft tissue, and then dissected free from its bony canal. Converse performed his step in the premolar region. The surgery is demonstrated in Illustration 5.
Step Body Osteotomy After Converse.

Illustration 5
Preservation of the inferior alveolar and mental nerves by removal of the outer table of the mandible after perforation by a round burr.

Converse's Reverse Step Body Osteotomy From Converse 1952.

Diagram 48

Converse and Shapiro (Converse & Shapiro 1952) later described a reverse step osteotomy, see diagram 48, and a retromolar step osteotomy, see diagram 49. A major disadvantage was the instability of the posterior fragment which often led to forward shifting of the same fragment, and this in turn meant a relapse of the deformity. There were two advantages to the retromolar osteotomy. First there was no need for the removal of teeth to accomplish the osteotomy. Second the procedure did not change the shape of the dental arch. Converse did advise that his retromolar osteotomy be done through an external (extra-oral) approach because of the general instability of the posterior fragment. Hinds and Kent (Hinds & Kent 1972) recommended that only oral approaches be used for body osteotomies of this nature and suggest either of two approaches: the free gingival flap or the degloving procedure developed by Converse (Converse 1964). See diagram 50.

Toman (Toman 1959) reported a double step osteotomy of the body of the mandible. He called his procedure the "Inlay
A. Retromolar osteotomy. The greater depth of the inferior alveolar nerve in this site is to be noted. B. After, reposition of the body of the mandible.

Converse's Retromolar Step Body Osteotomy
From Converse 1952.

Diagram 49

Osteotomy". Using an intra-oral approach, Toman performed a step osteotomy, bypassing the mental foramen as Converse (Converse 1950) did. Instead of completing the step to the lower border, Toman doubled back with a reverse step. The appropriate amount of bone was removed, and the indented step of the posterior fragment was "morticed" into the protruding step of the anterior fragment. See diagram 51. The fragments were not wired, but fixed with an occlusal splint.

Toman's procedure was subsequently reported by Neuner (Neuner 1976) in a review of mandibular procedures for the correction of prognathism. Neuner was of the opinion that the double
step body osteotomy was the most satisfactory body procedure for the correction of prognathism where there is a pronounced discrepancy between the two arches, and there is a partially edentulous maxilla.

Trauner (Trauner 1969) proposed a step body procedure, see diagram 52, that was adapted from Kazanjian's (Kazanjian 1936) procedure for the correction of retraction, see diagram 53. Trauner recommended that the procedure could be better used for the correction of moderate to severe protrusion. Trauner proposed that the procedure be performed through a Risdon type incision and that the bony cuts initially, be bur holes through the cortex only and the subsequent making use of a chisel or osteotome to complete the fracture. Hence there is less likelihood of damage to the neurovascular bundle which is then dissected free, and compartmentalised to avoid pressure. Fixation was achieved by superior to inferior border wires that were circumferential and/or interosseous across the fracture lines.
Trauner also proposed at the same time that mild to moderate protrusion where an open bite was present could be corrected with a second type of retromolar osteotomy. A wedge of bone could be removed that was bi-angled. The size and the angle of the wedge would be proportional to the degree of deformity and the amount of correction required. Trauner also suggested a curved section at the angle of the mandible together with an ostectomy in the retromolar region which was proportional to the degree of setback required. Trauner also suggested a more conventional wedge ostectomy of the body for the correction prognathism where accompanied by apertognathia, see diagram 54.
Operation for mandibular prognathism at the angle of the mandible with two \wire sutures in rectangular planes.

Trauner's Step Body/ Angle Osteotomy.
From Trauner 1969.

Diagram 52

As part of the general trend to the return of body procedures for the correction of prognathism, Onland and Merkx (Onland & Merkx 1972) in the first of two articles reported on the variety of deformities that were amenable to treatment by the use of body procedures. Deformities that were treated were prognathism, asymmetry and open bite. The second article reported fifty four cases treated for the correction of prognathism, twenty two of which were treated using a step body osteotomy.

Fordyce and Wedgwood (Fordyce & Wedgwood 1976) reviewed thirty patients treated with an intra-oral step osteotomy. The technique, developed from the step osteotomies for the correction of retrognathism, was used on the first patient five years previously. See diagram 55. Fordyce and Wedgwood emphasised the need to place bone mush (rather than bone chips) around the ostectomy site as part of the rapid union process. The approach was intra-oral, and used a muco-gingival flap based on the vestibule. All results were either satisfactory or acceptable both immediately and (for fifteen patients followed up) after one year or more.
Kazanjian's Step Body Osteotomy. From Kazanjian 1936.

Diagram 53

Relapse was discussed but in the surgeons' opinion there were no unacceptable results.

During the 1970's, there has been a revived interest in body osteotomies, step procedures in particular, for the correction of prognathism in particular, relevant to this chapter, as well as for the correction of other deformities. These will be mentioned in the relevant chapters. This new interest was reviewed by Sandor et al (Sandor, Stoelinga & Tideman 1982). Their review covered all aspects of the step body osteotomy in the correction of mandibular deformities.

Sandor et al advised that many of the disadvantages of the body procedures could be overcome by observing certain conditions. Conditions such as making use of edentulous spaces in the mandible; such as extracting non-restorable teeth; such as
Diagram 54

keeping the horizontal cut above the level of the mental foramen to minimize neurovascular damage; and such as avoiding the use of the reverse step osteotomy as this tended to create an unfavourable fracture and more likely to lead to post-operative open bite. The emphasis was on the requirement for flexibility of the surgeon to achieve the best possible result for the patient. Something only achieved where there is a careful study of the patient to find the procedure, or procedure variation that will best fit the patient. Hence there were certain indication for the use of the step body osteotomy for the correction of prognathism:

Diagram 55

1. Where there are edentulous spaces already present.
2. Where there are non restorable (or heavily restored - author) teeth in the lower arch.
3. Where for prosthetic purposes, relatively minor adjustments are required to the arch for a better maxillo-mandibular relationship.

Contra-indications were:
1. The presence of a steep mandibular plane (Ramus procedures then being preferred).
2. Where there is insufficient access between the apices of the teeth and the Mandibular neurovascular bundle.
3. Where a total body advancement would achieve a better result i.e. a ramus procedure. (Above from Sandor, Stoelinga & Tideman 1982).
"L" Osteotomy        "Reverse L" Osteotomy

Converse's "L" and "Reverse L" Osteotomies of the Body. From Converse and Wood-Smith 1964.

Diagram 56

As has been shown there is a large variety of techniques and technique variations showing the different types of cuts aimed at achieving a desired repositioning. Others not mentioned so far include the "L" osteotomy, with the step on, posterior or anterior to the mental foramen, and the "Reverse L" osteotomy, also with the step on, anterior or posterior to the mental foramen. See diagram 56. Indications for these procedures depends on:

1. The shape of the arch and therefore the need to change its final overall shape.

2. The position of prior edentulous spaces so that these may be used instead of removing other teeth to fit a standard procedure.

3. Accessibility of the proposed osteotomy site.

4. Indications in general for the use of a body procedure to correct the prognathic deformity.
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 apically and laterally. In second phase, two layers of compact bone are separated, neurovascular bundle is laid bare. "Exanomization" 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 57

Development of Sagittal Body Procedures.

Sada (Sada 1966) described a revolutionary sagittal split procedure on the body of the mandible for use in edentulous patients. The advantage of this technique was that intermaxillary fixation was not required through the use of a "ramomental" splint. The procedure was performed through an external approach posterior to the mental foramen. A rectangle of lateral cortical plate bone is removed as well as a similar amount of lingual cortical plate bone. The mandible is sagittally sectioned between the two ostectomies and the mandible retruded by the width of the cortical bone removed. The fragments are wired together. The denuded mandibular neurovascular bundle is deposited in the soft tissues from an artificial foramen at the inferior border of the posterior fragment. The bundle then

Diagram 58

curves around laterally and superiorly to re-enter the anterior fragment through a second artificial foramen just anterior to the lateral cortex osteotomy. See diagram 57. The "ramoment" suspension was placed through oral incisions on the anterior border of the ramus and in the canine region, bilaterally.

Reichenbach, Kölle and Bruckl (Reichenbach, Kölle & Bruckl 1970) also reported the sagittal split osteotomy of the body after a procedure that they attributed to Cohn-Stock. No reference was given. Mehnert (Mehnert 1967) reported a modified Sada technique for use of prognathic dentate mandibles. See diagram 58. All the above procedures had been used for the correction of prognathism. The body sagittal split procedure had many of the advantages of the ramus sagittal split procedure. There was a greater area of bony contact thus increasing the chances of bony union, and decreasing the time taken for union. This was an important consideration for body procedures which were known during the early procedures for a high
rate of non-union. The procedure also had the advantage of increasing the stability of the fragments, the proximal fragment in particular. There was also the general advantage of body procedures that the degree of relapse expected was lower that for ramus procedures as there was minimal interference of the pterygo-masseteric musculature, a major cause of relapse (see ramus procedures).

There were disadvantages that probably accounted for the procedure not being universally popular. The procedure was difficult to perform. There was still risk of damage to the mandibular neurovascular bundle and the consequent risk of permanent anaesthesia or paraesthesia. Teeth still needed to be taken out to allow adequate access to the surgical site as well as to allow the mandible to be retured. However further assessment reports may be expected as long term studies have not been reported to date.

The advantages and disadvantages of the body procedures have been discussed. Some of the advantages and disadvantages have remained as some procedures have stayed, but most have changed as general surgical improvements have effected. A comparison of early and current advantages and disadvantages is given below.

Smith and Johnson (Smith & Johnson 1940) listed the advantages and disadvantages of using body procedures over ramus procedures for the correction of prognathism. The advantages were:

1. Less hazardous
2. No Facial nerve paralysis
3. No salivary fistulae
4. Open bite and prognathism can be corrected at the same time
5. A wide arch can be corrected at the same time

The disadvantages were:

1. There were four bone divisions instead of two as in the ramus
2. There was the possibility of osteomyelitis especially if the wound compounded into the mouth
3. The difficulty in bone regeneration that can occur with bilateral fractures of the body
4. The possible displacement of the anterior fragment by the pull of the hyoid muscles
5. The requirement to remove teeth
6. Direct wiring can increase the chances of infection
7. Drains must be inserted through skin incisions
8. Resorption and/or infection can leave obvious scars
9. There is the possibility of severing the Mandibular nerve
10. Shortening of the lower arch can lead to tongue crowding
11. At least four intermaxillary wires are needed to secure fixation

Many of the disadvantages that Smith and Johnson noted are no longer important with the greater control of infection by the use of antibiotics. Smith and Johnson were in favour of ramus procedures. A comparison with Dingman (Dingman 1948) from the same era who was in favour of body procedures is given below. Dingman's advantages of the body ostectomy were:

1. The site of the ostectomy is very accessible
2. The sectioned bone can be removed without interfering with the mandibular neuro-vascular bundle
3. The procedure can be accomplished without oral contamination
4. The operation does not interfere with the muscles of mastication
5. There is more accurate and satisfactory repositioning of the fragments
6. A dental splint will hold the fragments after a short period of intermaxillary fixation

"The fact that osteectomy (sic) offers almost completely uniformly successful results with a minimum of effort and only slight possibility of complications, would indicate that this is the method of preference in most cases." (Dingman 1948). An indication of the strong views held.

In 1960 Rowe (Rowe 1960), described indications for the use of body procedures that have since been expanded on by others and are discussed later in the chapter. In Rowe's view the indications for osteotomy of the body of the mandible for the correction of prognathism were:

1. A short and narrow ramus.
2. A disproportionately long body.
3. When there is a gross deformity requiring a shifting of the mandible that is more than 1 centimetre.

Rowe's contra-indications were:

1. If there were to be an excessive loss of both bone and teeth when using the body procedure.
2. If there is insufficient vertical depth to the body from, for example, resorption of the bone. (This would lead to
insufficient bony contact, especially with a block section, and in turn lead to decreased healing and possibly non-union.

3. Where the gonial angle is so obtuse that when the anterior fragment is butted against the posterior fragment and the maxillary and mandibular teeth are in proper occlusal contact, there is insufficient bony surfaces in contact to allow good healing. This because with the removal of a block of bone, the posterior fragment could be substantially higher than the anterior fragment to give as much as a fifty percent loss of bone contact compared to surface available. Rowe noted that in extreme cases as this, wiring of the fragments is not recommended as an anterior open bite will usually result.

4. Where the lower border of the mandible is not parallel but markedly divergent to the occlusal plane. The resulting problem is the same as mentioned in 3.

5. Where there is the possibility of a tongue problem, as unlike ramus procedures that set back the mandible, the tongue is not retruded when body procedures are performed and there could be relapse problems due to tongue pressure.

Hinds and Kent (Hinds & Kent 1972) gave the following indications for the use of body procedures:

1. A large occlusal abnormality where correction of the deformity through the ramus, or without changing the arch shape, will not produce a satisfactory intermaxillary relationship. An example was molar crossbite as being not amenable to correction through the ramus.

2. Where the posterior occlusal relationships are satisfactory and there is no need for them to be altered. An example was where the body of the mandible is elongated.
Hinds and Kent noted that the advantages and disadvantages of body procedures made the indications noted above quite specific for the use of body procedures for the correction of prognathism.

The advantages were:

1. Ability to eliminate posterior crossbites.
2. There is minimal rotation of the condyles, and hence there does not appear to be any Temporomandibular joint problems.

The disadvantages were:

1. Possible non-union.
2. Possible delayed union.
3. Temporary or permanent anaesthesia of the lip.
4. No improvement of the gonial angle.
5. Any possible problem of macroglossia will be aggravated.

Fordyce and Wedgwood (Fordyce & Wedgwood 1976) in their report brought the advantages and disadvantages of the body procedure up to date, in particular the step ostectomy, for the correction of prognathism.

Their advantages briefly were:

1. There are no external scars as the approach is oral.
2. The pterygo-masseteric sling is not disturbed and therefore the tendency for relapse due to stretching of the ramus musculature or operating in the ramus is not present.
3. Union is rapid when a bone graft is used.
4. The configuration of the ostectomy produces an intrinsically stable upper arch.

The disadvantages of the operation were:

1. As the mandibular neurovascular bundle must be dissected out, there is the risk of permanent paraesthesia or permanent
anaesthesia.

2. There is a hazard to the teeth adjacent to the ostectomy site.

3. There is irregularity and shortening of the dental arch.

Fordyce and Wedgwood also felt that the main indications for the use of the body procedure were:

1. A large occlusal abnormality where correction of the deformity through the ramus, or without changing the arch shape, will not produce a satisfactory intermaxillary relationship. An example was molar crossbite as being not amenable to correction through the ramus.

2. Where the posterior occlusal relationships are satisfactory and there is no need for them to be altered. An example was where the body of the mandible is elongated.

Sandor et al (Sandor, Stoelinga & Tideman 1982) provide the most recent appraisal of the advantages and disadvantages to the step body osteotomy.

The advantages were:

1. Excellent visibility of the surgical site.

2. Therefore accurate bony cuts.

3. The procedure avoids the pterygo-masseteric sling and hence the concomitant oedema and haematoma associated with surgery to the sling area.

4. Relapse is less likely as the major muscles of mastication (the Pterygo-masseteric sling) are undisturbed.

5. The step procedures are more flexible allowing a wider range of movement of the fragments compared to whole body (ramus) procedures including altering lateral (e.g. crossbite) deformities, and vertical (e.g. stepped occlusal plane)
deformities at the same time.

The disadvantages were:

1. In some cases teeth must be sacrificed to provide access to the surgery site.
2. The surgery is near the Mandibular Nerve and hence the risk of damage is greater.
3. There is a risk to the apices of the teeth closely associated with the osteotomy cuts.
4. Disruption of the vascular supply to the teeth in the surgery area can lead to pulp necrosis.
5. Bone grafts are required to advance the mandible beyond more than a few millimetres.

Sandor et al examined a mixed (different deformities and different procedures) number of body procedures, ninety four surgical sites, and noted immediate paraesthesia in 68% of cases. At two years post-operatively this had shrunk to 9%. There were no numbers regarding the number of necrotic pulps resulting from the surgery, although it was conceded that it was a problem. On the good side, results were consistently stable, relapse put at 7% (no other figures given), no doubt helped by the placement of suitable fixed or removable prostheses that would provide long term fixation, something not possible with ramus procedures, and also by the lack of interference of the major masticatory muscles. (Sandor, Stoelinga & Tideman 1982).

Summary.

Body procedures for the correction of prognathism are partly returning to favour. They would appear to have a greater ability to resist relapse, and where there is a discrepancy in the
arch form, produce a better interarch relationship.

There is no strong evidence at this stage that the body procedure is better at avoiding paraesthesia or anaesthesia than the ramus procedures. On the contrary, at least in the immediate post-operative stages with the older procedures, the percentage of cases with paraesthesia or anaesthesia is generally higher in body procedures, compared to the ramus procedures and the vertical ramus procedures in particular. Newer techniques appear to have overcome many of the problems of post-operative paraesthesia and anaesthesia and future reports, especially long term studies, will be well anticipated.

Previously body procedures did have a poorer record of non-union compared to current ramus procedures, but this does not appear to be the case with the newer procedures, although it is too early to say as long term results with the newer body procedures have been sparsely reported on. Damage to other teeth can be a problem, although with proper care and sufficiently fine instrumentation this should not be a major disadvantage. In cases of major deformity affecting the angle of the mandible, body procedures are not suitable by themselves as they do not affect the gonial angle. Body procedures in combination with ramus/angle procedures may be required.

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MANDIBULAR RETROGNATHISM

Condyle Procedures

Introduction.

Treatment of retrognathism by surgical procedures performed on the condyle apart from the retrocondylar procedure described following, does not seem to have been popular. The earlier reports on the correction of retrognathism stressed the need for procedures to be performed on either the ramus or the body of the mandible.

This need was perhaps due to several factors. Firstly the limited success that condyle procedures had in the correction of prognathism. Secondly the correction of prognathism is less complicated than the correction of retrognathism due to the higher relapse rate associated with retrognathism. Thirdly the lack of bony contact between fragments when the mandible was protruded. Condyle procedures could only produce good results when minimal deformity was present.

Considering that retrognathism is more common than prognathism, there has been only one procedure that solely corrects retrognathism and is not an adaptation of a procedure for the correction of another type of deformity such as asymmetry: That procedure is the retrocondylar implantation procedure. This chapter is concerned only with the retrocondylar procedure for the correction of retrognathism using condyle procedures.

Discussion.
Drawings illustrating the incision for advancement of the lower jaw and the situation of the cartilage implant used.

Babcock's Retrocondylar Osteotomy with Implant. From Babcock 1937.

Diagram 59
The earliest reference that has been noted in relation to condyle procedures was an unsubstantiated reference in the Downs surgical catalogue that wood was used, in 1840, to replace a condyle excised for ankylosis. The mandible was substantially retruded as well as in permanent open bite. (Downs, Mayer & Phelps 1974).

Babcock (Babcock 1937) reported using a retrocondylar implantation using the resected zygoma, removed to obtain access to the joint, and the articular eminence, removed to allow forward movement of the joint, to provided the backstop for the head of the mandible to ensure anterior positioning of the mandible. The graft was placed between the anterior wall of the external auditory meatus and the articular head of the condyle. See diagram 59. Babcock noted that the joint was protruded quite readily and seemed to readily accommodate the displacement. There was little subsequent joint dysfunction according to Babcock. The initial advancement was approximately 8 millimetres and this was found to be unsatisfactory. Therefore seven days later the wounds were reopened, the implanted bone removed and costal cartilage, approximately 20 millimetres long, was re-implanted. The patient was happily chewing by the fourth day. There was no long term follow-up to determine the extent of subsequent joint function or dysfunction. It was Babcock's opinion that the procedure could be used for the correction of mild to severe retrognathism. Furthermore in the case of micrognathia ("Bird-face") Babcock recommended symphyseal grafting of fat or cartilage to correct the facial contour.

The procedure was almost identical to the one reported by Trauner (Trauner 1954) and again by Trauner and Obwegeser
Drawing of the temporomandibular joint. A. Between the anterior wall of the auditory meatus and the plesoid cavity lies a bone nodule, the fissura petrotypanica. Just below and above it the bone is perforated with a small drill. B. The piece of cartilage is fixed to the bone with wires going through this hole. The cartilage is situated close to the anterior wall of the bony auditory meatus.

A. B.

—A. Photograph of the piece of cartilage for the implantation, through which a steel wire is drawn, its ring lying at its lower end. B. On the upper level both wires perforate the cartilage on its lateral side close together.

Trauner's Retrocondylar Osteotomy. 1955.
From Trauner & Obwegeser 1957.

Diagram 60
Herbst's two-sided hinge with cap splints in both jaws. The two bars are fixed to the lower splint in front with screws, the two husks are fixed to the upper splints in the molar region. The mouth can be opened freely, but the mandible cannot slide backward of the intended position.

The Herbst Hinge Splint.

Diagram 61

(Trauner & Obwegeser 1957). Their technique required the use of a costal cartilage graft implanted between the articular process of the mandible and the anterior wall of the external auditory meatus. See diagram 60. The re-sited condyle was then anterior to its previous position by virtue of the graft and therefore the degree of correction obtainable depended on the size of the graft and the degree of forward movement permitted by the articular eminence. Fixation was by use of a Herbst hinge cast splint. See diagram 61. The purpose of the splint was to allow freedom of hinge movement of the mandible, but at the same time not allow retraction of the mandible and hence the condyle, back into its joint. The indication for the surgery was the correction of mild retraction. Unlike
Babcock's procedure the zygoma and the articular eminence were not removed. Babcock himself admitted that it was not necessary to remove the zygoma.

Banks (Banks & Ardouin 1980) published a preliminary report which included a review limited only by the lack of prior references. Banks and Ardouin did miss one report by Gonzalez-Ulloa (Gonzalez-Ulloa & Stevens 1968) who reported the retrocondylar implant procedure using acrylic blocks to achieve the protrusion of the mandible. Gonzalez-Ulloa and Stevens recommended the procedure for the correction of severe retrognathism where the advancement of the symphysis by 20 millimetres or more is required. The amount of protrusion able to be corrected by this procedure would appear to be excessive when compared to other surgeons reported below. There were no long term studies reported.

Banks and Ardouin stated that Trauner reported a total of 30 cases either by himself or in association with others, three of which were performed with acrylic blocks rather than cartilage grafts. Trauner was of the opinion, according to Banks, that no intermaxillary fixation was required and eventually the fossa remodelled itself. (Trauner & Dupuis 1967: Trauner 1969). In contrast to his earlier reports of mild advancement (3 to 5mm), later reports, according to Banks, indicated that advancement up to 10 mm. could be achieved (moderate retrognathism). Poswilló (Poswillo 1968) was achieving a satisfactory 15 mm., for the correction of what may be considered severe retrognathia. In Banks' nine cases, three were of 10 mm. and one was of 12 mm. (Banks & Ardouin 1980).

In view of the lack of muscle stripping from the
mandible, and the limited amount of protrusion obtainable, indications for the operation would appear to be: (a) a requirement for not more than 10 mm. of advancement, (b) growth not yet completed, and (c) the dental arches in normal contour. This procedure is not widely accepted. Perhaps in part due to the possible physiological complications such as:

1. Disruption to the masticatory muscles.
2. Disruption to the condylar capsule due to excessive stretching of the capsule.
3. Consequent disruption of the masticatory reflexes, many of which are stretch dependent.
4. The unseating of the condyle head from the glenoid fossa.

All of the remaining authors who have reported on this procedure have been French and reported in the French literature, (Lachard & Vitton 1973; Lenart 1968; Vitton, Gola, Blanc & Lachard 1973), including the co-author of one of Trauner's reports (Trauner & Dupuis 1967).

Summary.

The limited criteria for the retrocondylar procedure (normal gonial angle, normal mandibular arch form, and minimal deformity), compared to its disadvantages, do not make the procedure a commonly reported one. While not having been fully reported on, consideration has to be given to the relative complications of the pre-auricular approach to the condyle compared to the oral approach to the body, and that more severe deformities can be corrected by a body procedure for less possible complications when compared to a condyle procedure.
MANDIBULAR RETROGNATHISM

Ramus Procedures

Introduction.

The early ramus procedures for the correction of retrognathism were slow to develop as many of the earliest cases were corrected using body procedures. It was not until Limberg and then Kostecka developed the subsigmoid procedures albeit for the correction of apertognathism, that the use of ramus procedures for the correction of retrognathism began to advance rapidly.

The turning point is probably about the late 1940's to the early 1950's when ramus procedures became the preferred type of procedure for the correction of retrognathism. By the 1970's the use of multiple procedures for the correction of unusual or very severe problems became more common in the literature.

Like body procedures, many of the procedures used for the correction of retrognathism were also used and mainly developed for the correction of prognathism. There were several notable exceptions to the rule. Babcock's retrocondylar osteotomy is one example. Most procedures were adaptations of prognathism correction procedures usually with the addition of grafts to make up for the deficient bone.

Discussion.

Development of Horizontal Ramus Procedures.

Lane (Lane 1906) has been credited by a number of
Blair's Horizontal Ramus Osteotomy. 1905.
From Blair 1915.

Diagram 62

authors (Hinds & Kent 1972, Hensel 1937) as being the first to perform the horizontal, near flat, osteotomy of the ramus for the correction of retrognathism. Lane has been credited not only with being the first to perform the procedure, but also with using a bone plate screwed into the ramus across the bony cut for fixation. The procedure was performed using an external approach but the there were no specific details.

The next noted reference to the correction of retrusion using a ramus procedure was by Blair who performed his procedure in 1905 (Blair 1907). The osteotomy that was reported was a horizontal sectioning of the ramus above the level of the lingula. See diagram 62. Blair used a blind external approach later used by Kostecka, and described by Kostecka nearly thirty years later. (Kostecka 1931). Blair was of the opinion that the procedure was best used for the correction of retrusion only. The correction of protrusion, he thought, was best accomplished by a body procedure. (Blair 1921, Blair & Ivy 1923).