Chapter 16: Craniofacial anomalies

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The term craniofacial anomalies literally encompasses all congenital deformities of the cranium and face. More specifically, however, the term has come to imply congenital deformities of the head that interfere with physical and mental well-being (Marsh and Vannier, 1985). There are practically no epidemiological studies of craniofacial malformations as such. Myrianthropoulos (1982) reviewed data gleaned from epidemiological studies of malformations that were selected 'because of their careful design, large number of observations and high degree of ascertainment'. On this basis, there appear to be of the order of 175 major craniofacial malformations per 10,000 births, and the proportion of craniofacial malformations out of all malformations is about 21%.

The initial attempts at surgical correction of facial deformity were directed at the mandible. Osteotomies of the mandible have been described at every part of the bone in order to achieve forward, backward, or rotational repositioning of the constituent parts. These techniques have been comprehensively reviewed by Rowe (1960). The most universally useful technique has proved to be the sagittal splitting osteotomy introduced by Trauner and Obwegeser (1957), with later modifications by Dal Pont (1961) and Hunsuck (1968).

The first maxillary osteotomies used to correct facial deformity were at the Le Fort I level, and the development of this procedure has recently been reviewed by Drommer (1986). Gillies performed the first craniofacial dysjunction at the Le Fort III level in 1942 (Gillies and Harrison, 1950). Obwegeser explored the techniques of subcranial facial osteotomy during the 1950s and 1960s, laying the foundations for the routine surgical correction of the great majority of cases of facial deformity (Obwegeser, 1969).

During the 1960s, Tessier devised advanced techniques for the surgical correction of the craniofacial deformity which afflicted patients suffering from the craniosynostosis (Tessier, 1967). These patients, while comparatively few in number, suffer particularly severe forms of craniofacial deformity. Both Obwegeser and Tessier exploited subcranial osteotomies, but Tessier also addressed the problem of orbital hypertelorism. Segmental orbital rim movements had been used by a number of surgeons, but the results were unsatisfactory. Tessier reasoned that successful surgical correction required mobilization of the orbit posterior to the equator of the globe of the eye, and that this required a combined intracranial and extracranial approach. Tessier and his neurosurgical colleague Guiot, were the first surgeons to reposition the bony orbits by a courageous craniofacial approach (Tessier et al, 1967). Surgeons from all parts of the world subsequently journeyed to Paris to learn from Tessier before returning home to help develop the discipline of craniofacial surgery, of which he is the undisputed father.

Classification of craniofacial anomalies

Developments in craniofacial surgery in turn stimulated interest in the classification of craniofacial anomalies. Hitherto, descriptions of patients with such deformities were reported as individual cases, as groups of patients having similar collections of clinical signs
(malformation syndromes), and as part of voluminous textbooks containing extensive lists of various types of facial dysmorphology.

Craniofacial anomalies can be broadly divided into three main subgroups:

- the craniosynostoses
- craniofacial clefts
- miscellaneous craniofacial anomalies.

The craniosynostoses

At birth the cranial sutures are non-ossified zones between the bony plates of the cranial vault and the various small bones of the cranial base which appear as radiolucencies on routine skull radiographs. The sutures were originally considered to be the primary site of growth of the bony cranium, but they are not thought to be tension-responsive zones that deposit bone in response to intracranial expansion. The sutures remain biologically active for variable periods of time postnatally before fusing on a predictable schedule. Craniosynostosis is the term used to describe premature fusion of one or more cranial sutures in utero.

The incidence of craniosynostosis is not precisely known. In a World Health Organization study, several participating centres reported this condition with an incidence ranging from one in 4500 to one in 30,000 births; yet another study quoted an incidence of one in 2000 births (Myrianthopoulos, 1982).

Three types of craniosynostosis are described.

Primary craniosynostosis

This may be found as an idiopathic developmental error occurring in otherwise normal individuals. It also occurs as part of complex syndromes involving other developmental aberrations; such syndromes often show Mendelian inheritance. It should be noted, however, that there is no familial incidence in the large majority of cases of primary craniosynostosis.

Secondary craniosynostosis

A failure of brain growth as in microcephaly or an encephaloclastic process occurring during the first years of life will result in premature fusion of the cranial sutures. A similar process may also be seen when severe hydrocephalus has been treated with a low-pressure shunt.

Metabolic craniosynostosis

Metabolic craniosynostosis results from premature sutural fusion determined by obvious biochemical disorders such as the mucopolysaccharidoses, rickets, hypophosphatasia or hypercalcaemia.
Pathology of craniosynostosis

From a pathologist's point of view, craniosynostosis can be regarded as a normal developmental process occurring at an abnormally young age. There is little or nothing in the suture pathology to suggest that the process differs fundamentally from normal suture closure. Histological studies of the sutures have concentrated mainly on those of the cranial vault, but it has become increasingly evident that, in many cases of craniosynostosis, the basal sutures are also involved.

The cranial deformities which are seen in the craniosynostoses represent the secondary pathology of the condition. The volumetric capacity of the skull is unlikely to be reduced by the premature fusion of one or two sutures, but when multiple sutures are involved, the cranial volume is affected. In this latter case, the skull shows pathological changes indicative of raised intracranial pressure. These include convolutional impressions (circular or oval areas of thinning of the cranial vault seen on skull radiographs as 'hammer or copper beating') and the formation of small cerebral herniae in areas of even more defective cranial development. The variations in skull shape consequent upon the premature fusion of specific sutures will be discussed below.

Changes in the brain, the organs of special sense and the facial viscera may be regarded as the tertiary pathology of craniosynostosis. Much concern over the condition relates to possible detrimental effects on the brain. There are few convincing reports of cerebral damage directly related to the distorted shape of the cranium, but minor degrees of cerebral damage would escape detection at post-mortem. Serious cerebral anomalies are most often found in association with the genetically determined craniosynostoses, especially Apert syndrome. The chief secondary neuropathological complication is hydrocephalus, which may be severe enough to demand treatment. Vision may be affected and perhaps mentality. When the cranial capacity is reduced, the term craniostenosis is applied.

Symptomatology

Where medical and nursing scrutiny is routine and effective in the neonatal period, the majority of cases of craniosynostosis are diagnosed early. In a minority of patients, usually where the deformities are mild, the diagnosis may be delayed. A variety of signs and symptoms are associated with craniosynostosis.

Raised intracranial pressure

This is an important but relatively uncommon feature of craniosynostosis, with the associated symptoms of headache, failing vision and mental deterioration. Papilloedema is a very serious clinical finding, and is most likely to develop early in life, when there is maximum disproportion between the volume of the growing brain and the capacity of the stenosed skull. Mental changes occur in less than 20% of cases, and there is poor correlation between mental status and the severity of the craniosynostosis.
Exorbitism and orbitostenosis

Exorbitism, or the protrusion of the orbital contents anterior to the bony orbit, is a feature of some cases of the complex craniosynostosis syndromes. The magnitude of the exorbitism varies between specific diagnoses as well as between individuals with the same syndrome. The orbital volume is reduced by encroachment of the roof, lateral and medial walls, reflecting disturbed bony development within the anterior and middle cranial fossae secondary to craniosynostosis; this reduction in orbital capacity is sometimes termed orbitostenosis. In addition, the orbital floor is hypoplastic as a result of the severe maxillary retrusion often seen in these syndromes.

Exorbitism, apart from being unsightly, may interfere with function. The extrinsic ocular muscles, especially the medial recti, work at a disadvantage; there is a strong tendency to divergent squinting and binocular vision is frequently impossible. Exorbitism may be sufficiently marked to prevent lid closure during sleep, leading to keratitis and the danger of blindness. Thus sight may be in danger from both corneal damage and optic atrophy secondary to raised intracranial pressure. In some patients the globe is so proptosed that it may become dislocated through the palpebral fissure, when manual reduction may be necessary.

Orbital hypertelorism

Greig (1924) coined the term hypertelorism to describe what he thought was a discrete syndrome consisting of excessive separation between the eyes. Greig's nomenclature of ocular hypertelorism has not been replaced by the term orbital hypertelorism in order to exclude excessive interpupillary distances secondary to exotropias. It should be distinguished from telecanthus, an increased distance between the medial canthi, which is frequently encountered in severe nasoethmoidal trauma. Orbital hypertelorism is not a primary anomaly per se, but is found in a number and variety of diseases and malformation syndromes, most notably the craniosynostoses and craniofacial clefting syndromes. There is some evidence to suggest that the severity of hypertelorism progresses in craniosynostosis, whereas it remains constant with growth in patients with clefting. Not only is orbital hypertelorism unsightly, but there may be functional impairment of binocular vision and convergence.

The diagnosis depends on defining deviation from normality, usually two or three standard deviations from the mean. Various measurements such as intercanthal distance and interpupillary distance, standardized for age and sex, are used to measure such deviation. The distribution of these differs in various ethnic groups. For example, intercanthal and interpupillary values for Negroes significantly exceed those for Caucasians. On this basis, Myrianthropoulos (1982) suggested an incidence of one per 1000 births.

Hypertelorism has been classified according to the degree of separation of the medial orbital walls measured at the anterior lacrimal crests on standard radiographic projections. In first degree hypertelorism the interorbital distance is 30-34 mm which is clinically insignificant. In second degree hypertelorism the interorbital distance is 34-40 mm which is clinically obvious, while a distance of greater than 40 mm signifies third degree hypertelorism which is unusual in craniosynostosis, but is seen in association with frontonasal dysplasia (see
below). In this extreme state the orbits may appear to face laterally as well as forward, in which case the ocular movements are impaired.

**Orbital hypotelorism**

An interorbital distance below the normal range (22-30 mm in the adult) is likely to give the eyes a close-set appearance known as hypotelorism. It results from excessive medial migration of the orbits due to inadequate development of the frontal cribriform area as a result of either metopic craniosynostosis or neural hypoplasia. Vision is not affected.

**Orbital dystopia**

The term dystopia literally refers to an aberrant position of the globe. Orbital dystopia implies a displacement of the bony orbit in one or a combination of the axial (transverse), coronal (mediolateral) and sagittal (anteroposterior) planes; the malposition is usually associated with a degree of rotation. Dystopia may be a feature of the craniosynostoses or of the clefting syndromes such as Treacher Collins syndrome and craniofacial microsomia.

**Midface hypoplasia**

Craniosynostosis and midface retrusion are common features of a number of specific syndromes, most of this also include deformities of the hands and feet. The membranous components of the facial skeleton fail to grow normally, while the cartilaginous components are largely unaffected. Consequently, relative overgrowth of the nasal septum may produce a prominent, often deviated nose with obstruction of the nasal airway. Delaire et al (1963) have applied the term faciostenosis to describe these states of midface hypoplasia. While it is not yet certain that this hypoplasia results from premature fusion of the facial sutures, the concept of faciostenosis is useful, as it emphasizes that affected patients suffer from disorders of visceral function analogous to those seen in craniostenosis and orbitostenosis.

**Airway restriction**

Maxillary hypoplasia is a three-dimensional phenomenon. The maxilla is narrow transversely, resulting in a narrow and frequently high-arched palate. The retruded position of the maxilla reduces the postnasal space, while diminishing vertical height lowers the capacity of the nasal cavity and paranasal air sinuses; in addition, choanal atresia may occur in cases of Crouzon syndrome. Some of the severely affected children may experience sleep apnoea, while older patients are often mouth breathers who snore unduly. It is possible that respiratory distress may cause some infant deaths, especially in Apert syndrome, which carries a high infant mortality rate.

**Speech**

Severe midface retrusion can have marked effects on speech. Adequate accommodation of the tongue is precluded by the narrow palate, especially if there is an accompanying palatal cleft - a non uncommon association. Velopharyngeal incompetence is not usually a feature, but may occur in association with a cleft or after large surgical advancements of the maxilla. Crowding of the nasopharyngeal airway and varying degrees of nasal obstruction are common
in Crouzon syndrome, and this can result in hyponasal speech. Hypoplastic paranasal sinuses may reduce vocal resonance, while severe dental malocclusions add to the articulation problems caused by the abnormal tongue position. Impaired hearing is a common finding in Apert and Crouzon syndromes, and this can adversely affect the acquisition of normal speech, as may mental retardation.

**Mastication**

The skeletal disproportion between maxilla and mandible, and the accompanying dental malocclusion, can seriously impair normal mastication. It should be noted that, although there is an apparent mandibular prognathism, the mandible is usually abnormally small in patients with craniosynostosis syndromes. This has important implications for surgical reconstruction, as it is frequently necessary to advance both maxilla and mandible to produce a satisfactory facial harmony.

**Simple calvarial deformities**

There is considerable variation in the shape and size of heads, and when these variations are extreme, they are considered to be deformities. Such a judgement is essentially intuitive, and obviously varies in different ethnic groups and in different cultures. The *cephalic index* (more strictly the horizontal cephalic index), defined as \((\text{maximum breadth/maximum length}) \times 100\) offers a useful means of quantitating a visual impression; the dimensions may be measured clinically or from skull radiographs. It will be obvious that it is very difficult to quantitate cranial asymmetry.

All cranial vault sutures and fontanelles are patent in the normal neonatal skull. They ossify and become radiopaque in an orderly, but variable sequence, as follows:

**Sutures** - metopic (childhood); sagittal, coronal and lambdoid (adulthood); squamosal, occipitomastoid and sphenotemporal (may be patent in the elderly).

**Fontanelles** - posterior and anterolateral (infancy); posterolateral (during first year of life); anterior (during second year of life).

The shape of the skull may be significantly deformed by premature fusion of the cranial sutures. One must be careful to exclude cranial moulding which usually improves with time, while craniosynostosis becomes progressively more obvious.

The various types of calvarial deformity are summarized in *Table 16.1*. Sagittal synostosis is the most common, representing about 55-60%, with coronal synostosis being the next most common (20-30%). Metopic, lambdoidal and combinations of premature sutural fusions are far less frequent. While these cranial deformities are found in isolation, they frequently form part of one of the craniosynostosis syndromes described below.
Table 16.1 The various types of calvarial deformity

<table>
<thead>
<tr>
<th>Affected suture</th>
<th>Sagittal</th>
<th>Metopic</th>
<th>Unicoronal</th>
<th>Bicoronal</th>
<th>Multiple sutures</th>
<th>Oxyccephaly</th>
<th>Kleeblattschädel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional name</td>
<td>Scaphocephaly</td>
<td>Trigonocephaly</td>
<td>Plagiocephaly</td>
<td>Brachycephaly</td>
<td>Turricephaly (acrocephaly)</td>
<td>Sharp skull</td>
<td>Clover-leaf skull</td>
</tr>
<tr>
<td>Literal translation</td>
<td>Boat skull</td>
<td>Triangle skull</td>
<td>Oblique skull</td>
<td>Short skull</td>
<td>Tower skull</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Skull length</td>
<td>Increased</td>
<td>Normal or Increased</td>
<td>Decrease or normal</td>
<td>Increased</td>
<td>Decreased</td>
<td>Increased</td>
<td>Increased</td>
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<tr>
<td>Skull width</td>
<td>Normal or Increased</td>
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<tr>
<td>Skull height</td>
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<td>Increased</td>
<td>Normal</td>
<td>Increased</td>
<td>Normal</td>
<td>Increased</td>
<td>Increased</td>
</tr>
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</table>

Craniosynostosis syndrome

Cohen (1979) listed 57 craniosynostosis syndromes, as well as 22 combinations with secondary or occasional craniosynostosis. Simple calvarial deformities may be accompanied by unusual facial appearances, but they are primarily dysplasias of the cranium. Cases of identifiable craniofacial syndrome may present with deformities of the skull vault and minimal facial disturbance.

The commonest of the craniofacial syndromes is Crouzon syndrome which primarily affects the craniofacial region. There are a number of craniofacial syndromes in which craniosynostosis occurs together with syndactyly, the most important of these being Apert syndrome. A significant proportion of the cases of craniofacial syndromes are familial, usually exhibiting autosomal dominant transmission.

Only the commoner syndromes will be described. For an overall perspective of the various craniosynostosis syndromes the reader is referred to the excellent review article by Cohen (1979). A fuller account of the craniosynostoses is provided by David, Poswillo and Simpson (1982).

Crouzon syndrome

Although Friedenwald reported a case of steeple head with prominent eyes in 1893, Crouzon, in 1912, was the first to delineate the triad of calvarial deformity, midface hypoplasia and exorbitism. Crouzon syndrome, also called craniofacial dysostosis, has autosomal dominant transmission, but up to 50% of cases occur sporadically, representing fresh mutations.

Clinical features

Cranium

Patients may exhibit any of the forms of calvarial deformity, depending on which sutures are involved, the chronological order in which they fuse and the extent of their involvement. The brachycephalic deformities predominate, but it is important to remember that many cases of the syndrome show no obvious calvarial deformity, even when there are marked radiological abnormalities.

Premature and progressive craniosynostosis is variable in onset, but frequently commences during the first year of life and is usually complete by 2-3 years of age. Radiographically, the coronal and sagittal sutures are nearly always involved, while the
lambdoidal suture is affected in 80% of cases; other findings include digital markings (90%), basilar kyphosis and widening of the pituitary fossa. The basal sutures may also fuse prematurely. While this is hard to demonstrate radiographically, post-mortem studies have revealed premature fusion of the sphenofrontal sutures (Kreiborg and Bjork, 1982), a finding which has been confirmed during surgery. Such sphenofrontal craniosynostosis is an important feature of orbitostenosis, since failure of growth across this suture results in reduced anteroposterior depth of the orbit. Cephalometric studies frequently indicate short calvaria, a steep forehead and flattened occiput; often there is protrusion in the area of the anterior fontanelle (the clown's cap deformity) which exaggerates the oxycephalic head shape. The cranial base is commonly short and narrow with the clivus especially shortened.

The signs of raised intracranial pressure may be evident, with headaches noted in 30% and epilepsy in 10%. While some cases of mental impairment result from this increased pressure, the extent to which mental deficiency exists de novo is uncertain.

**Face**

Midface hypoplasia with relative mandibular prognathism, drooping lower lip and short upper lip are typical features. The nasal bridge is often flattened, and the tip of the nose may appear beak-like. There is deviation of the nasal septum in 35% and obstruction of the nasopharynx in 30% of cases.

**Oral findings**

These include a narrow high-arched palate, crowding of the dental arches and an anterior open bite. Ectopic eruption of the maxillary first molar teeth occurs in about half of the patients, and 35% are obligate mouth breathers. Some 3% of patients exhibit a cleft palate and 10% have a bifid uvula.

**Eyes**

Proptosis is a constant finding, being secondary to the shallow orbits. Divergent strabismus, nystagmus and hypertelorism are frequently found. Exposure conjunctivitis (50%), keratitis (10%), poor vision (45%) and optic atrophy (25%) are reported; rarely there is luxation of the globes.

**Ears**

More than 50% of patients have a conductive hearing loss associated with malformed auditory ossicles, and some 15% patients have atresia of the auditory canals.

**Other anomalies**

Stiffness of the joints, especially the elbows, has been reported. Cervical spine anomalies occur in 30% of patients, and 85% exhibit calcification of the stylohyoid ligament.
Differential diagnosis

Having no abnormalities of hands or feet, Crouzon syndrome is easily distinguished from Apert or Pfeiffer syndromes. It may be confused with Saethre-Chotzen syndrome in which the hand and feet anomalies may be minimal or absent. It should also be distinguished from simple craniosynostosis.

Apert syndrome

In 1896 Apert observed an infant with a very brachycephalic head and severe syndactyly affecting all four limbs; by the time he described the case 10 years later (Apert, 1906), eight similar cases had been reported. Apert called the condition *acrocéphalosyndactilie*. The anglicized form *acrocephalosyndactyly* is now usually used to embrace all those syndromes which have the common features of craniosynostosis and digital anomalies. Apert syndrome is distinguished from other acrocephalosyndactylies by the severity of the syndactyly, which involves fusion of the phalanges of at least the index, middle and ring fingers. An incidence of about one in 160,000 has been suggested, but due to high infant mortality, there is probably a significantly lower incidence in the general population. Most cases are sporadic, but there is autosomal dominant inheritance in some cases, and increased paternal age at the time of conception has been found. Prenatal diagnosis has been made by fetoscopy, when hand and foot anomalies have been noted.

Clinical features

Cranium

In typical cases the head is turribrachycephalic, with a high forehead and flattened occiput; the apex of the cranium is located near or anterior to the bregma. There is often a congenital bone defect in the metopic region, and consequently there may be a soft tissue bulge extending from the fontanelle to the roof of the nose. There is invariably premature synostosis of the coronal sutures, and there may be additional premature fusion of the squamosal and sagittal sutures, but these are less obvious and usually appear later. The clivus is disproportionately small, and there is an associated shortening of the posterior fossa, but this may become less evident with growth. Post-mortem studies appear to indicate that the cranial malformation is determined before the sutures begin to fuse, and there are various patterns of synostosis in the chondrocranial components of the skull base. David, Poswillo and Simpson (1982) have suggested that in Apert syndrome there is some more fundamental perversion of skull growth than is seen in other forms of craniosynostosis, perhaps due to an underlying biochemical defect in chondrogenesis.

Some degree of mental retardation is found in most patients, although normal intelligence has been observed in some cases. It appears doubtful that cerebral damage results purely as a result of compression by the unyielding skull, and the basis of the mental retardation in Apert syndrome remains unclear.
**Face**

The facial dysplasia is severe, especially in older patients. The maxilla is grossly hypoplastic, while the nose and mandible are relatively prominent. Facial asymmetry is sometimes present, and can be very pronounced.

**Oral findings**

The palate is usually highly arched, constricted and may have a median furrow. The soft palate is cleft in about one-third of cases, and a bifid uvula is occasionally seen. The maxillary dental arch may be V-shaped, with severe dental crowding and bulging alveolar ridges. A skeletal class III malocclusion is almost invariable, and an anterior open bite is often seen. Retarded dental eruption is common. All these deformities, together with mental impairment, frequently combine to impair speech.

**Eyes**

Hypertelorism is common, and there is usually some degree of proptosis. All degrees of orbitostenosis are seen in Apert syndrome, but it is not generally as severe as in Crouzon syndrome. The palpebral fissures may show an antimongoloid slant.

**Skeletal system**

Deformities of the hands and feet are symmetrical. A mid-digital hand mass with bony and soft-tissue syndactyly of digits two, three and four is always found; in addition, digits one and five may be joined to digits two and four respectively. The interphalangeal joints of the fingers are stiff, while fingernails of the mid-digital hand mass may be continuous or partly continuous. In the feet, toes two, three and four are joined by soft-tissue syndactyly; toes one and five may either be joined by soft-tissue syndactyly to the second and fourth toes respectively. Toenails may be partially continuous with some segmentation.

The upper extremities are shortened, and there may be aplasia or ankylosis of several joints, especially the elbow, shoulder and hip. Progressive synostosis of the bones of the hands, feet and cervical spine have been reported. The epiphyses of the long bones are frequently dysplastic.

**Other findings**

Acne vulgaris commonly occurs, with extension to the forearm. Fixation of the stapes is frequently seen, and a variety of cardiovascular and other internal anomalies have been reported.

**Differential diagnosis**

The syndactyly of Apert syndrome is much more severe and consistent than in other craniosynostosis-syndactyly syndromes such as Pfeiffer, Sathre-Chotzen and Carpenter syndromes. The hands and feet are normal in Crouzon syndrome.
Pfeiffer syndrome

In 1964, Pfeiffer described a syndrome consisting of craniosynostosis with turribrachycephaly, broad thumbs and great toes, and partial soft-tissue syndactyly of the hands and feet as a variable feature. Pfeiffer's report described eight affected individuals in three generations, with two instances of male-to-male transmission. The pedigree indicated autosomal dominant inheritance. It has since become clear that this relatively rare syndrome exhibits complete penetrance and variable expressivity. Sporadic cases have been reported, but no increased paternal age effect has been noted. Since Pfeiffer's original description, a variety of additional craniofacial features have been added.

Clinical features

Cranium

Turricephaly is the commonest deformity, being associated with premature fusion of the coronal sutures. Other sutures may be involved, and cases with trigonocephaly and clover-leaf skull have been recorded.

Intelligence is usually normal, but mental retardation does occur, being most severe in those cases associated with clover-leaf skull.

Face

Maxillary hypoplasia with relative mandibular prognathism is common, and the ears are frequently low-set. Facial asymmetry, orbital hypertelorism, antimongoloid palpebral fissures, proptosis and strabismus have all been reported.

Oral findings include a high-arched palate, dental malocclusion and, rarely, a bifid uvula.

Hands and feet

The thumbs and great toes are broad, and usually show varus deformity. In some patients the great toes may be shortened, but without varus deformity. Cutaneous syndactyly is usually present, involving digits two and three, and at times three and four, of both hands and feet. Clinodactyly and symphalangism of both hands and feet have been reported. Other skeletal anomalies described include fused cervical vertebrae, radiohumeral and radioulnar synostoses.

Other anomalies

Other features occasionally seen are pyloric stenosis, bicuspid aortic valve, hypoplasia of the gallbladder, single umbilical artery, umbilical hernia, preauricular tags, choanal atresia and hearing loss.
Differential diagnosis

Pfeiffer syndrome should be distinguished from other craniosynostosis - syndactyly syndromes, notably Apert and Saethre-Chotzen syndromes. Facialy it is similar to Apert syndrome, but in the latter, the degree of syndactyly is extreme and characteristic. The facial findings of asymmetry, low hairline and beaking of the nose in the Saethre-Chotzen syndrome are not typical of Pfeiffer syndrome. In Crouzon syndrome the hands are normal, while in Pfeiffer syndrome the thumbs and great toes are typical.

Treatment of the craniosynostoses

The most contentious debate in craniofacial surgery remains that concerning the timing of the various forms of surgery available. Regrettably, despite the fact that such surgery has now been practised for more than 20 years, there are no good objective and scientific studies indicating the long-term results in respect of the obvious parameters of brain and cranial growth, facial growth, eyesight and mental ability. Surgery has been performed at all ages from the neonatal period to adulthood, and the results presented have been largely anecdotal.

There is general agreement that the two conditions which make early surgery mandatory are raised intracranial pressure and the danger of visual impairment due to gross exorbitism. The aims of early craniofacial surgery for craniosynostosis are:

(1) to allow the brain to expand normally
(2) to provide a normal shape to the forehead and skull
(3) to provide eye protection by reducing the exorbitism
(4) to prevent or minimize the problem of impaired facial growth in faciostenosis.

Marchac and Renier (1981) reported the results of early surgery (preferably within the first 6 months), claiming good morphological and functional results that appeared to be maintained over periods up to 8 years (their longest follow-up period). Surgery involved frontal bone advancement by their 'floating forehead' technique and reshaping of the cranium. The photographs appear impressive, but no objective measurement of either morphology or function was made. They also claimed that 'there is a definite improvement of either morphology or function was made. They also claimed that 'there is a definite improvement in affected facial structures when early surgery has been performed', but no evidence is produced. The severe midface retrusion seen in the craniosynostosis syndromes is almost certainly due to involvement of the sutures of the cranial base, and it is difficult to see how surgery which corrects the cranial vault can have any effect on the growth of the midface.

Patients with hypertelorism lack stereoscopic vision. Tessier (167) originally suggested that, if the hypertelorism could be corrected by early surgery, this may result in the acquisition of stereoscopic vision; unfortunately, this does not appear to be the case. Seventy per cent of the adult interorbital distance is reached by the age of 2 years in the normal person, and it is thus assumed that surgical correction of hypertelorism is best delayed until after this age. The results of surgery for hypertelorism depend on the anatomy of the specific deformity and the skill of the surgeon.
Faciostenosis or midface retrusion, apart from producing severe facial deformity, may result in the functional problems of corneal exposure, impairment of breathing and poor mastication. There are obvious advantages to correcting the deformity early, both from a cosmetic and functional point of view. However, this presents some technical problems, and it is almost certain that further correction will be necessary at a later date. Provided that everybody involved in the decision is aware of these constraints, it appears reasonable to agree to early surgery in appropriate cases. Undoubtedly better results are obtained in those cases in which surgery is delayed until after puberty.

Details of surgical technique are outside the scope of this chapter, and have therefore not been included. Henderson (1985) covers the subcranial osteotomies comprehensively, and Caronni (1985) is a good source for information about cranial and orbital techniques.

Craniofacial clefts

Cleft is a useful word for conveying the mechanism of a malformation, or the resultant features of the deformity. While clefts of the lip and palate are relatively common, there are a number of other clefts occurring in the craniofacial region which are rare. For many years the terminology for these conditions was confusing, and often misleading. Terms such as nasomaxillary hypoplasia and frontonasal dysplasia were used, and adjectives such as orofacial, oronasal and otomandibular employed. Some malformations may bear many names, while others are subjected to eponymous terminology such as Treacher Collings and Goldenhar syndromes.

Numerous attempts have been made to classify craniofacial defects, but none has proved entirely satisfactory. Tessier (1976) devised a descriptive, clinical classification that is unrelated to the embryology of the malformation. It is based on his personal observation of 336 cases of craniofacial clefts. His analysis of this vast and unique collection of rare conditions included clinical and radiographic examination; in 254 cases he carried out an anatomical dissection at the time of surgery. As a result of this work Tessier found that true bony clefts were present where 'hypoplasia' had previously been described, this being the case in both Treacher Collins syndrome and craniofacial microsomia. Bone and soft tissues were rarely involved to the same extent; between the midline and infraorbital foramen soft tissue defects were the more destructive, while lateral to this (with the notable exception of the auricle) bony defects were more severe. Clefts were located along some very definite axes; due to the constancy of most skeletal points, clefts are more easily described with reference to the skeleton than to the soft tissues.

**Tessier classification**

Tessier utilized the eyelids and orbits as a reference when describing clefts, as this enables both cranium and face to be included. His original diagrams present a graphic representation of the classification.

For the purpose of orientation, the orbit is divided into two hemispheres. The lower lid with the cheek and lip constitutes the southern hemisphere, and clefts through it are facial. The upper lid is in the northern hemisphere, and clefts through it are cranial. Using the number zero as the mid-sagittal plane, each site of malformation has been assigned a
respective number determined by its axis in relationship to the zero line. Fifteen locations for
clefts (0-14) have been described, using the orbit as the point of reference. They are
distributed according to eight 'time zones', cleft number seven being the most lateral. Cleft
lip is not specifically described, but is encountered in most instances of clefts 1, 2 or 3. For
specific details of the classification, readers are referred to Tessier's original paper.

It should be remembered that the spectrum of prevalence of the anomalies
encompassed within the above classification varies from very uncommon to extremely rare.
Selection has therefore been exercised, and only the 'commoner' conditions seen in a
craniofacial unit have been included.

Frontonasal dysplasia

This condition, also known as median cleft face syndrome, is an ill-defined syndrome.
It is a non-specific developmental alteration, in which the defect occurs with a host of low-
frequency anomalies (Goodman and Gorlin, 1983). Frontonasal dysplasia corresponds to clefts
0 and 14 in Tessier's classification. The main features are orbital hypertelorism, broad nasal
root, lack of formation of the nasal tip, widow's peak hair anomaly and anterior cranium
bifidum occultum. Sedano et al (1970) published a comprehensive review of the condition,
and applied the term frontonasal dysplasia.

The basic defect is unknown. Embryologically, if the nasal capsule fails to develop,
the primitive brain vesicle fills the space normally occupied by the capsule; this produces
anterior cranium bifidum occultum, a morphokinetic arrest in the positioning of the eyes and
lack of formation of the nasal tip. Most cases of this condition are sporadic. Both autosomal
inheritance and multifactorial transmission have been proposed, but the genetic mode of
inheritance remains unclear. It is not known why twinning is commoner in families with
frontonasal dysplasia than in the general population.

Clinical features

The facial malformation presents variable clinical combinations, and varies from mild
to severe. Orbital hypertelorism is a constant finding, and secondary telecanthus or narrowing
of the palpebral fissures occurs in severe cases. Epibulbar dermoids are common, while
anophthalmia, microphthalmia, upper eyelid colobomas and congenital cataracts occur rarely.
The anterior hairline may extend in a V shape onto the centre of forehead (widow's peak).
Nasal deformities vary from colobomata of the nostrils to nasal flattening, with widely spaced
nares and a broad nasal root. Other findings include median cleft of the upper lip (cleft palate
is rare), preauricular tags, low set ears, absent tragus and conductive deafness.

Mental deficiency is present in some cases, being more likely when the hypertelorism
is severe or when extracephalic anomalies are present. Anterior cranium bifidum may be seen
radiographically. A large anterior meningoencephalocele, and rarely lipoma or teratoma, is
sometimes associated with frontonasal dysplasia. Craniosynostosis and brachycephaly have
been reported, together with a variety of cerebral anomalies.

Outside the craniofacial region occasional findings include polydactyly, syndactyly,
clinodactyly, umbilical hernia and cryptorchidism.
Differential diagnosis

Orbital hypertelorism should be regarded as a non-specific malformation that may occur in a variety of different syndromes. Peterson et al (1971) have listed a variety of disorders in which orbital hypertelorism is a feature. Bifid nose can occur with hypertelorism, several familial cases having been reported. When epibulbar dermoids, eyelid colobomas and preauricular tags are present, frontonasal dysplasia should be distinguished from craniofacial microsoma.

Treatment

Seventy per cent of the adult interorbital distance is reached by the age of 2 years in the normal person. It is thus generally assumed that surgical correction of hypertelorism should be delayed until after this age. In the majority of cases the optic canals are the normal distance apart. Occasionally they are wider apart, and this is usually associated with an increase in width of the cribriform plate. Before any surgery is contemplated it is thus important that a precise assessment of the orbital anatomy is made. For a resumé of imaging techniques the reader should consult Marsh and Vannier (1985). The place of magnetic resonance imaging has not yet been fully determined.

For details of the surgical technique for the correction of orbital hypertelorism the reader is directed to a text on craniofacial surgery, for example, Caronni (1985).

Median cleft lip with orbital hypertelorism

This rare syndrome is also known as holoprosencephaly, arhinencephaly and median facial dysgenesis. It results from impaired sagittal cleavage of the forebrain into cerebral hemispheres. There exists a whole spectrum of midline face-brain anomalies ranging from the extreme cyclopia (one central eye), through cebrocephaly (orbital hypertelorism and a single blind-ended nostril nose) and premaxillary agenesis (hypotelorism, a flat boneless nose and a medial cleft lip) to the less severe forms of midline facial dysmorphia. In all forms the incidence is about one in 15,000 births, and the frequency may be as high as one in 250 conceptuses from spontaneous abortion. Chromosomal anomalies are common in this group of disorders, and the majority of cases are sporadic. Some mild examples have exhibited Mendelian inheritance. The more severe forms do not survive long enough to reproduce.

Clinical features

The characteristic features of the syndrome are:

1. complete median cleft lip with absent premaxilla and prolabium
2. flat nose with absent columella, septal cartilage and nasal bones
3. orbital hypotelorism
4. mongoloid slant of the eyes
5. fusion of eyebrows in midline, and sparse frontal hair
6. forebrain formed by a single large ventricle with little cerebral cortex
7. a cleft palate may be present.
Treatment

Severe cases do not survive infancy, and many do not live past childhood. Most exhibit a moderate to severe degree of mental retardation. The degree of facial involvement usually, but not always, predicts the extent of brain malformation. It will thus be obvious that extensive treatment is unrealistic. Where appropriate, lip closure may be helpful.

Lateral and oblique facial clefts

Lateral facial cleft

This relatively rare cleft runs from the angle of the mouth towards the tragus of the ear, although its course is variable. It results from failure of fusion of the maxillary and mandibular processes of the first branchial arch. It may be present as a shallow furrow throughout, or extend as a complete cleft into the oral cavity as far as the anterior border of the masseter muscle. There may be hypoplasia of the muscles of mastication, as well as of the maxilla, zygoma and auricle. Both Treacher Collins syndrome and craniofacial microsomia are forms of lateral facial clefting (Tessier no. 7); the macrostomia seen in the Goldenhar variant of craniofacial microsomia is an obvious manifestation of this cleft.

Oblique facial cleft

Boo-Chai (1970) has subdivided these extremely rare clefts into:

1. naso-ocular cleft, extending from the nostril to the lower eyelid border with possible extension to the temporal region (along the line of closure of the nasolacrimal groove)

2. oro-ocular cleft, extending from eye to lip. There may be a further subdivision into medial and lateral types, depending on the relationship to the infraorbital foramen.

About 25% of these rare clefts are bilateral.

Treatment

Treatment usually consists of one or more Z-plasties to bring tissue into the cleft. Eyelid colobomas are treated in the usual way by excision of the edges and closure of the defect.

Amniotic band disruption complex

The amniotic band disruption complex occurs in various forms. The most common involves the limbs only, but the complex embraces a spectrum ranging from a ring constriction of the finger to major craniofacial and visceral defects. The most severe combination of anomalies in this disorder includes limb and craniofacial abnormalities acronymically termed the ADAM (amniotic deformity, adhesions, mutilations) complex. The incidence is estimated between one in 5,000 and one in 10,000 for all forms of the complex,
and craniofacial examples are obviously much rarer. There is no evidence that a genetic factor is involved.

The most common hypothesis concerning the complex is that the fetal deformities result from primary amnion rupture without chorionic sac damage at various stages of gestation. The placenta and membranes are often abnormal; fibrous strands attached to the amnion or chorion have been observed, and rarely, a band is attached to the infant. The earlier the amniotic rupture, the more severe the anomalies.

Facial anomalies include cleft lip (usually bilateral), bizarre midfacial clefts, hydrocephalus, microcephalus, multiple anterior encephalocoeles and meningocoeles. Eye abnormalities include distorted or colobomatous palpebral fissures, microphthalmia, anophthalmia and corneal opacity. There may be complex nasal malformations, and major visceral anomalies comprise omphalocoele and gastroschisis.

Treatment

The prognosis depends on the severity of the deformities. Many of those with the ADAM complex die, and mental retardation is common with central nervous system involvement. Due to the wide variety of clinical features, treatment plans have to be applied on an individual basis.

Craniofacial microsomia

This condition is also known as hemifacial microsomia, first arch syndrome, first and second branchial arch syndrome, otomandibular dysostosis, oculoauriculovertebral dysplasia, Goldenhar syndrome and lateral facial dysplasia. Most of these terms convey the erroneous impression that involvement is limited to facial structures, whereas cardiac, renal and skeletal anomalies may occur in addition. The condition was first reported by von Arlt in 1881. Gorlin et al (1963) used the term hemifacial microsomia to refer to patients with unilateral microtia, macrostomia and failure of formation of the mandibular ramus and condyle; they suggested that oculoauriculovertebral dysplasia (Goldenhar syndrome) was a variant, characterized by vertebral anomalies and epibulbar dermoids. From a craniofacial viewpoint, the most recent appellation of craniofacial microsomia proposed by Converse et al (1977) has the merit of avoiding the implication that the condition is unilateral (it is frequently bilateral), and it emphasizes that the cranium may be involved.

Regardless of the preferred name, this diagnostic group includes a wide spectrum of phenotypes. Although craniofacial microsomia is usually sporadic, familial cases are known, with a variety of transmission patterns. The incidence is reported as between one in 5000 births with a 1:1 sex ratio. In about 70% of cases the anomaly is unilateral. When it is bilateral it is always asymmetrical, a notable difference from Treacher Collins syndrome.

Poswillo (1973, 1974), using an animal model, demonstrated that destruction of differentiating tissues in the region of the developing ear and jaws by a teratogenically induced, expanding haematoma produced a branchial arch dysplasia. The severity of the dysplasia was related to the degree of local destruction. Thus craniofacial microsomia should probably be regarded as a non-specific symptom complex, the pathogenesis of which has
several different aetiologies. When cardiac, renal or skeletal anomalies coexist, there appears to be an increased chance of genetic involvement.

**Clinical features**

Not uncommonly the infants are small-for-dates, and there may be feeding difficulties which, on occasions, can necessitate tube feeding. In rare cases, nocturnal sleep apnoea may be severe enough to require tracheostomy.

**Facies**

The facies may be striking because of the asymmetry. This may be partly due to hypoplasia and/or displacement of the pinna, but the degree of involvement varies markedly. The maxilla, zygoma and temporal bones on the affected side are reduced and flattened. Frontal bossing is common, and the ipsilateral eye may be set lower than its neighbour. The chin point is frequently deviated to the affected side due to mandibular hypoplasia, and the asymmetry can be further enhanced by hypoplasia of the parotid gland. Macrostomia, when it occurs, is usually mild. Some 30% of patients with craniofacial microsomia have bilateral involvement, but the disorder is always more severe on one side.

**Oral findings**

Patients may exhibit all degrees of hypoplasia of the mandible, from a minimal decrease in size to complete agenesis of the ascending ramus and portion of the body on the affected side. When the condyle is absent, there is concomitant absence of the glenoid fossa. The gonial angle is often flattened, and this is a reflection of the decreased activity of the masticatory muscles. Moss and James (1984) have shown that there is a significant correlation between muscle activity and the morphology of the ascending ramus. The dental occlusal plane is frequently canted, and the degree of cant is a reflection of the severity of the mandibular and maxillary hypoplasia. Moss and James also found that the angle of the occlusal plane was negatively correlated with muscle activity, and that, in unilateral cases, the deficiency of growth on the affected side was compensated by overgrowth of the other side. In bilateral cases, the occlusal plane is usually normal or only mildly canted, but in such cases the chin is often severely retruded. In infants, when severe micrognathia is present, there is a risk of obstructive sleep apnoea. This risk is enhanced when the pharynx is hypoplastic.

As well as hypoplasia and/or paresis of the palatal muscles, the tongue may be similarly affected, resulting in some degree of collapse of the dental arches. The incidence of cleft lip and palate is usually quoted as less than 10%, but at the Hospitals for Sick Children, Great Ormond Street, London the incidence is 18% in a group of some 60 patients.

**Neuromuscular system**

Hypoplasia of the masticatory muscles is present in all but the mildest cases, the masseter, temporalis and medial pterygoid being the most frequently involved, though to a variable degree. Facial weakness, usually affecting the lower face occurs in 10% of patients; palatal and tongue musculature are less commonly affected. The incidence of mental retardation is reported as 10%, and occasional cases of occipital encephalocele are recorded.
Ear

Malformations of the external ear may vary from complete aplasia to a crumpled, distorted pinna displaced anteriorly and inferiorly. Supernumerary ear tags can be found anywhere from the tragus to the angle of the mouth; ear tags may be bilateral, especially when epibulbar dermoids are present. Conductive hearing loss due to middle ear abnormalities and/or absence or deficiency of the external auditory meatus is found in some 40% of patients.

Eye

The palpebral fissure is often somewhat lowered on the affected side. Epibulbar dermoid and/or lipodermoid is a variable finding. It is milky-white to yellow in colour, flattened, ellipsoidal and usually solid rather than cystic. The dermoid is frequently located at the limbus or corneal margin in the lower and outer quadrant; by contrast, the lipodermoid is usually located in the upper and outer quadrant. In some patients both lesions are seen in the same eye. Unilateral coloboma of the upper lid is common in patients with epibulbar dermoids (it will be remembered that in Treacher Collins syndrome colobomata occur in the lower lid). Choroidal or iridial coloboma and congenital cystic eye can occur in this disorder. Microphthalmia and anophthalmia are associated with severely affected individuals in whom mental retardation is more common.

Skeletal anomalies

Vertebral anomalies are found in about half the patients, and include occipitalization of the atlas, cuneiform vertebrae, complete or partial synostosis of two or more vertebrae, supernumerary vertebrae, hemivertebrae and spina bifida. Anomalous ribs, talipes equinovarus and other skeletal defects have been reported.

Other anomalies

Some 50% of affected patients have various forms of congenital heart disease (Gorlin, Pindborg and Cohen, 1976). This can be severe enough to preclude corrective facial surgery. Pulmonary agenesis or hypoplasia has been noted on the affected side. A variety of renal abnormalities can be associated with the condition, including absent kidney, double ureter and anomalous blood supply.

Differential diagnosis

This disorder should be distinguished from Pierre Robin anomaly and Moebius syndrome. Bilateral cases of craniofacial microsomia are frequently confused with Treacher Collins syndrome; such confusion may be avoided if it is remembered that the former condition is asymmetrical, while the latter is symmetrical. Colobomas occur in the upper eyelid in craniofacial microsomia and the lower lid in Treacher Collins syndrome. Epibulbar dermoids may also be observed in frontonasal dysplasia.
Treatment

Three main problems have to be faced when considering surgical correction of craniofacial microsomia:

(1) No general agreement exists regarding the best time to carry out reconstructive surgery. At one extreme are those who maintain that all treatment for these patients should be deferred until growth is complete, the argument being that the shortage of investing soft tissues will inevitably cause relapse during the growing stages. Others maintain that enlargement of the deficient mandibular ramus during growth (usually by serial bone grafting) will help stimulate any growth potential that may be present in the soft tissue.

(2) The hypoplasia seen in craniofacial microsomia affects all tissues, both hard and soft. Thus any bony reconstruction has to be planned within the constraints of limited soft tissue (functional) matrix.

(3) Facial asymmetries in general are more difficult to correct than horizontal or vertical disproportions. The fact that the hypoplasia of craniofacial microsomia affects all tissues presents one of the most difficult problems facing the maxillofacial surgeon.

The following observations reflect the author's view about the management of this difficult problem.

(1) In moderate to severe unilateral cases, complete symmetry can never be achieved.

(2) Early surgery is indicated in those patients who demonstrate activity in the masticatory muscles. Ideally, electromyography should be carried out. If this investigation is not available, the presence of certain indicators favours early surgery; these indicators are the presence of a condyle (however rudimentary), a reasonably sized coronoid process, a masseteric process at the angle of the mandible and a degree of antegonial notching, however slight (Towers, 1976). Very early surgery to the midface is better delayed due to the danger of damage to the developing tooth buds filling the maxilla, and the lack of patient cooperation for postoperative orthodontics. Mandibular surgery, however, can be performed at any time, but is better delayed until cooperation for functional orthodontic treatment is possible. If possible, the start of a 'growth spur' is a useful time for surgical intervention.

(3) In unilateral cases of craniofacial microsomia the unaffected side is not 'normal'. It undergoes hyperplasia in order to compensate for underdevelopment of the affected side (Moss and James, 1984). In reconstruction it is important not to try to make the involved side the same length as the 'normal' side; some reduction in height of the longer side is advisable.

(4) The constraints of the restrictive soft-tissue envelope may be managed by redistributing the bones within it, and not trying to introduce too much increase in bony volume. The reduction in lower face height referred to in (3) will assist this process. If the above process is not possible, it will be mandatory to introduce soft tissue into the area.

(5) The bulk of a bone graft, whether it is vascularized or not, will only survive if subjected to the stimulus of muscle activity. Thus the quality of the masticatory muscles on
the affected side is an important index of the prognosis for bone graft survival. When onlay bone grafts are used, cranial bone survives better than either rib or iliac crest - the two usual sources of bone for reconstruction (Zins and Whitaker, 1983).

(6) The concept of the transfer of vascularized composite flaps containing both bone and soft tissue has received much attention recently. Vascularization of a bone graft in the absence of muscle activity will not ensure its survival. Similarly, muscles will atrophy and become fibrotic when they lack a nerve supply. The definitive assessment of a series of these flaps is awaited with interest, but the optimism of some enthusiasts appears to ignore proven physiological concepts. Despite the above reservations, the microvascular transfer of soft tissue appears to offer definite advantages over other techniques when surface cover or soft-tissue bulk is required.

(7) Much time and effort is devoted to ear reconstruction. In the author's experience the results are usually disappointing and sometimes frankly mutilating. When the time comes for correction of the major part of the deformity, both parents and child are sometimes disillusioned and resentful. It is time that the allocation of so much surgical time and effort in pursuit of such disappointing results should be questioned.

For details of the surgical techniques currently employed in the treatment of craniofacial microsomia, the reader is referred to texts by Caronni (1985) and Henderson (1985).

Treacher Collins syndrome

Synonyms for this condition include mandibulofacial dysostosis, Berry syndrome, Franceschetti-Zwahlen-Klein syndrome and bilateral facial agenesis. Although the syndrome was probably first described by Thomson in 1846 (Gorlin, Pindborg and Cohen, 1976), credit for its discovery is usually given to Berry or, more commonly, to Treacher Collins, who described the essential features of the syndrome in 1900. Franceschetti and Klein (1949) coined the term mandibulofacial dysostosis.

The syndrome is inherited as an autosomal dominant trait with high penetrance and marked variability in expressivity. More than half the cases arise as fresh mutations, but before being so assigned, careful examination of family members should be performed, looking for minimal signs of the syndrome. The abnormal gene may have a lethal effect, since miscarriage or early postnatal death is common. Poswillo (1974) used an experimental model to formulate an explanation for the causal mechanism of Treacher Collins syndrome. He found that there was early destruction of the neural crest cells of the facial and auditory primordia which migrate to the first and second branchial arches. This destruction, before migration is well under way, leads to the formation of a 'vacuum' in the area of the otic cup into which the surrounding tissues flow. The developing otic pit thus moves upwards into the first arch region and relocates over the angle of the mandible. Additionally, there is a symmetrical, overall hypoplasia of many of the derivatives of the first and second branchial arch mesenchyme.
Clinical features

Facies

The facial appearance is characteristic. The obliquely slanting palpebral fissures, depressed cheekbones, deformed pinnae, receding chin and large, fish-like mouth present an unforgettable picture. One-quarter of affected patients have tongue-shaped process of hair that extends towards cheeks. The body of the malar bones may be totally absent, but more often is grossly and symmetrically underdeveloped, with discontinuity of the zygomatic arches. The paranasal air sinuses are usually small, and may be absent. The lower orbital rim is sometimes defective, giving support to Tessier's assertion that Treacher Collins syndrome is a clefting syndrome. The nasofrontal angle is usually obliterated, with a high nasal bridgeline. The nose appears large due to the lack of malar development, while the nares may be narrow and the alar cartilages hypoplastic.

Oral manifestations

The mandible is almost always hypoplastic, with the deficiency mainly in the ascending ramus; the gonial angle is high, and antegonial notching is seen. There is a downward curve in the body of the mandible and, together with the short ramus, this results in gross retrusion of the chin. There is usually a high-arched palate, 30% of which are cleft. Macrostomia, seen in 15% of cases, may be unilateral or bilateral. Dental malocclusion is common; the teeth may be widely separated, hypoplastic, displaced or associated with an anterior open bite.

Eyes

There is an antimongoloid obliquity of the palpebral fissures, and a coloboma is present in the outer third of the lower lid in 75% of patients half of whom also have a deficiency of eyelashes medial to the coloboma. Iridal coloboma may also occur. The lower lacrimal points, Meibomian glands and intermarginal strip may be absent. Microphthalmia has been reported.

Ears

The external ear is frequently deformed, crumpled forward or misplaced. Some patients exhibit an absence of the external auditory canal or ossicular defects resulting in conductive deafness. Anomalies of the ossicles include a fixed malleus, fusion of malformed malleus and incus, monopodal stapes, absence of stapes and oval window; there may be complete absence of the middle ear and epitympanic space. Extra ear tags and blind pits may be found anywhere between the tragus and angle of the mouth.

Other anomalies

Those other abnormalities reported include absence of the parotid gland, congenital heart disease, malformed cervical vertebrae, defects of the extremities, cryptorchidism and renal abnormalities. Mental retardation does occur, but in some cases this may be secondary to a severe hearing deficit.
Differential diagnosis

The most important distinction is from bilateral craniofacial microsomia. Treacher Collins syndrome is a symmetrical facial deformity, while craniofacial microsomia is never symmetrical. Other isolated and rare syndromes may exhibit some of the facial features seen in Treacher Collins syndrome, and the 'commonest' of these is acrofacial dysostosis (Nager syndrome).

Treatment

Poswillo (1974) argued persuasively that the early reconstruction of the hypoplastic facial skeleton in Treacher Collins syndrome will permit expansion of the modified functional matrix. While the skeletal structures of the mid- and lower face are morphologically deficient, their design is such that in the presence of a system of masticatory muscles there exists a reasonable functional matrix capable of growth and development after surgical reconstruction. Occasionally very early surgery is mandatory when obstructive sleep apnoea is precipitated by the severe micrognathia.

Surgery is directed at three main areas:

(1) the eyes, with antimongoloid slant of the palpebral fissures and lower lid colobomas

(2) the malar hypoplasia

(3) the mandibular hypoplasia with the marked retrognathia and anterior open bite.

For details of the techniques involved, readers should consult an appropriate craniofacial text such as that by Caronni (1985).

Miscellaneous craniofacial anomalies

Some craniofacial anomalies cannot be classified as one of the craniosynostoses or a clefting syndrome. These disorders include dysplasias, hamartomata, certain benign neoplasms and a miscellany of specific syndromes. The conditions described in this section do not constitute a comprehensive list of all the possibilities, but include most of the conditions that are seen from time-to-time in a busy craniofacial unit, and which are usually amenable to some form of surgical correction, albeit with variable degrees of success. The disorders are variable in extent, the spectrum extending from discrete areas to massive involvement of a large portion of the craniofacial region.

Dysplasias of bone

The most interesting and extensive of these conditions are fibrous dysplasia and cherubism.
Fibrous dysplasia

Fibrous dysplasia of bone may affect the bones of the cranial and face in three ways:

1. as a monostotic lesion
2. as one or more of the lesions of polyostotic disease
3. as one or more of the lesions of Albright's syndrome, in which the polyostotic lesions are accompanied by such manifestations as cutaneous pigmentation, endocrine disorders with precocious puberty and premature skull maturation.

The nature and aetiology of fibrous dysplasia are unknown, but the consensus of opinion at present regards it as a developmental defect. There is no evidence to suggest that the lesions are neoplastic, and they tend to become inactive or stabilized after the normal period of skeletal growth has come to an end. Fibrous dysplasia is not inherited, but there is a definite sex predilection, two to three times as many females being affected.

Distribution of lesions

In monostotic cases, practically any bone may be involved, but limb bones, ribs, jaws and cranial bones are those most frequently affected. In polyostotic fibrous dysplasia the skull is involved in about half the cases in which there is a moderate degree of skeletal involvement, while in severe cases the skull is constantly involved. While almost any combination of lesions may occur, there is a well-marked tendency for the lesions to occur segmentally, with localization in one limb or on one side of the body. When the jaws are involved, the lesion is usually solitary, occurring more often in the maxilla than the mandible. Multiple jaw lesions are less frequent, but when they occur may be accompanied by lesions in the facial and cranial bones.

Clinical features

Patients with polyostotic disease that is at all extensive practically always present as children, usually with deformity or pathological fracture. When solitary or relatively few lesions exist, presentation is usually in childhood or adolescence, but occasionally this is delayed until adult life. Jaw lesions occur as bony hard, non-tender swellings that expand the jaw, producing a gradually increasing facial asymmetry that may be first noticed by the parents. Often the deformity is slight, even when the lesion has ceased to be active. However, in some cases growth is more rapid and extensive, and in a comparatively short time there may develop a large mandibular swelling or a maxillary lesion that causes marked swelling of the cheek, exophthalmos or nasal obstruction. It is probable that many of the cases previously termed leontiasis ossea were examples of fibrous dysplasia.

Radiology

Radiographic appearance in the jaws are generally similar to those seen in other bones. Both radiolucent and ground glass appearances are seen. On intraoral films a characteristic
orange peel picture is seen in those areas that appear as a ground glass appearance in extraoral films. Diffuse lesions in the maxilla and facial bones may extend up to, and distort, the suture lines, but do not cross them. Skull radiographs in jaw cases frequently show that there is an increased density at the base of the skull.

Pathology

The lesions are yellowish or greyish-white, and impart a gritty sensation to the knife when cut. Microscopically they consist of fibrous tissue that replaces normal bone and gives rise to osseous trabeculae. The proportion of fibrous to bony tissue varies from case to case and in different areas of the same lesion. It has been suggested that the proportion of fibrous tissue diminishes with the increasing age of a lesion, while calcification increases; this is no more than a trend, and is not necessary a regular occurrence.

Differential diagnosis

This condition is sometimes confused with cherubism, but a careful family history and clinical examination of the jaws augmented by radiographic examination should clarify the situation. Fibrous dysplasia occurs in a totally different age group from Paget's disease, and the serum chemistry is within normal limits. Examination of biopsy material by an experienced oral pathologist should clinch the diagnosis.

Treatment

In the craniofacial region treatment is usually instituted for cosmetic reasons rather than for functional disability. Whenever possible, treatment should be deferred until after puberty when the progressive enlargement of the affected areas usually ceases. In some cases, due to the rapid progress of disease, it is necessary to intervene before maturation of the lesions; in this situation it may be necessary to repeat the surgery, sometimes several times, and at varying intervals.

Contouring of the affected areas is the treatment of choice. The consistency of lesions varies widely, some being amenable to paring with a scalpel, while others are hard enough to require shaping with osteotomes or mechanical instruments. On rare occasions, orbital and frontal bone involvement may necessitate a transcranial surgical approach.

Cherubism

This condition was first described by Jones in 1933 as familial multilocular cystic disease of the jaws, but the term cherubism, coined by the same author, has gained wider acceptance. Lucas (1984) provided a good review of the condition. The familial incidence of cherubism is one of its characteristic features, probably being inherited as a dominant trait with variable expressivity. Males are affected twice as frequently as females. Children with cherubism appear normal at birth, but swellings appear in the jaws between 1 and 4 years of age; the mandible is always affected, and very often the maxilla. The lesions rapidly increase in size up to the age of about 7 years, then enter a static phase or progress slowly up to puberty. The facial appearance is then said to improve, despite abnormal radiological appearances.
Clinical features

Facial deformity is the chief complaint. There is a characteristic fullness of the cheeks and jaws, and there is often a slightly upturned appearance to the eyes, with a rim of sclera visible beneath the iris. This latter sign is due to involvement of the orbital floor causing upward displacement of the eyeball and loss of support for the lower eyelid. The upturned eyes and full cheeks produce a cherubic appearance. The submandibular lymph nodes are generally enlarged, and the cervical nodes are also sometimes involved. There is fibrous enlargement of large areas of the jaws, resulting in gross expansion and irregularity. The resulting irregular bulges are painless and non-tender. Expansion of the mandible may elevate the tongue and cause a degree of speech impairment. The maxillary involvement is variable, sometimes being sufficiently extensive to produce nasal obstruction or ocular proptosis. The dentition is almost always abnormal.

Radiology

Radiographic appearances in the jaws are characteristic. Multiloculated radiolucencies produce considerable expansion of the bone; the loculi are sharply defined, and crossed by bone septa. The thinned and expanded cortex may be deficient in some areas without periosteal new bone formation.

Pathology

The tissue that replaces normal bone is soft, fibrous or friable, and mottled reddish-brown or greyish-brown. The main constituent of the lesion is fibrous tissue arranged in a whorled pattern. Giant cells are concentrated around the numerous thin-walled blood vessels that permeate this vascular lesion. The enlarged lymph nodes show reactive changes only.

Differential diagnosis

The main distinction is from fibrous dysplasia. Cherubism is almost always familial, and the lesions are bilateral. As in fibrous dysplasia, it is important that any biopsy material is examined by an experienced oral pathologist.

Treatment

Management is essentially the same as that described for fibrous dysplasia. Surgery should be conservative, and only performed before puberty when absolutely necessary.

Angiomatous malformations

Haemangioma

The appellation haemangioma, although generally accepted, is taxonomically erroneous, as the anomaly is a hamartoma rather than a true neoplasm. Haemangiomata are usually classified as capillary and cavernous, although mixed types are common. It is beyond the scope of this chapter to deal with them in a systematic way; rather, the discussion will
be limited to those large, cavernous or mixed haemangioma that occupy a substantial area in the craniofacial region and produce a significant deformity.

**Clinical features**

Facial cavernous or mixed haemangioma may present as a very superficial, comparatively flat tumour at birth. They may enlarge slowly, but 60-70% of lesions regress completely by the age of 8 years if the parents will permit this approach. The occasional overwhelming lesion that has microarteriovenous fistulae demonstrates no regression, but continues to grow and expand. It rapidly develops a deeper cavernous element until the whole or large part of the face becomes involved. The distended tissues may bulge out in the eyelids and around the mouth, so that the eye is completely hidden and the mouth may be partially obstructed. The skin and musculature of the face are greatly stretched, and feeding may become very difficult.

**Differential diagnosis**

This condition may be confused with lymphangioma, neurofibroma and congenital hemihypertrophy of the face. In young children it is important to exclude rhabdomyosarcoma (50% occur before the age of 5 years, and 25% are in the head and neck region). If any doubt exists, a biopsy is justified.

**Treatment**

Treatment of large facial haemangioma should be embarked upon with considerable circumspection. The help of a neuroradiologist can be invaluable, both in terms of defining the extent and nature of the lesion, and also carrying out microembolization with muscle or microspheres. This latter procedure is seldom anything other than transitory in its effect, but it permits surgery under much more favorable conditions, thus reducing the operative risk. The results of surgery in such large lesions are usually disappointing. Occasionally, however, favourable results are obtained. For cavernous lesions that are not excessively large, Matthews (1968) advocated the use of saturated saline as a sclerosing fluid. The use of radiotherapy in children is to be condemned.

**Klippel-Trenaunay-Weber syndrome**

The aetiology of this syndrome, also called vascular gigantism, is unknown, and almost all cases are sporadic. The original description defined the Klippel-Trenaunay-Weber syndrome as consisting of unilateral extremity enlargement with cutaneous and subcutaneous haemangioma, varicosities, phlebectasia and occasionally arteriovenous fistulae. The syndrome has since been expanded to include almost every body area; many additional abnormalities have been recognized, including lymphangiomatous anomalies, macrodactyly, syndactyly, polydactyly, oligodactyly and abdominal haemangioma (Gorlin, Pindborg and Cohen, 1976).

Craniofacial involvement is rare, but when present is similar to that seen in Sturge-Weber syndrome, both in distribution and the degree of variability. Patients may exhibit
mental retardation when cutaneous involvement is present. Occasionally the jaws may exhibit bony enlargement.

**Differential diagnosis**

Neurofibroma must be excluded, since limb hypertrophy and cutaneous haemangiomata may be associated with it; café-au-lait spots do not occur in Klippel-Trenaunay-Weber syndrome. Hemi hypertrophy and cutaneous haemangiomata occur in both Beckwith-Wiedemann syndrome and Maffucci syndrome. Vascular anomalies of the skin have also been reported in true congenital hypertrophy.

**Treatment**

Most patients do reasonably well. Some form of soft-tissue reduction such as filleting may be necessary; care should be exercised, as wound healing is usually delayed and skin infarction is common. For this reason, considerable circumspection is necessary when dealing with facial lesions. In cases with severe disproportionate growth in a limb, epiphyseal fusion or removal of a gigantic digit may be necessary. When gigantic extremities are gross enough to produce disseminated intravascular coagulation or evidence of high-output cardiac failure, amputation may be essential (Thomson, 1979).

**Sturge-Weber syndrome**

This syndrome is a non-hereditary condition that has neither sex nor ethnic predilection. It is characterized by:

1. unilateral venous angiomatosis of the leptomeninges
2. ipsilateral facial angiomatosis
3. ipsilateral gyriform calcifications of the cerebral cortex
4. seizures, hemiplegia and mental retardation
5. ocular defects.

A port-wine stain on the ipsilateral side of the face occurs in 90% of individuals, and this may extend onto the neck, chest and back. The colour varies from pink to purplish-red and rarely decreases in intensity with age.

Seizures, usually focal and rarely generalized, have been observed in 90% of patients. The symptoms appear during infancy on the side contralateral to the angiomatosis. Hemiparesis is less frequent. Mental impairment affects at least 30% of patients, being more severe with widespread cerebral involvement. Ophthalmic complications include choroidal angioma and glaucoma, both of which are fairly common.

**Differential diagnosis**

The relationship between Sturge-Weber and Klippel-Trenaunay-Weber syndromes is not usually a problem, but the two may coexist, and could represent the same basic disorder in a different site (Goodman and Gorlin, 1983). Transitory port-wine stains are very common in the neonatal period, but dark supraorbital involvement should arouse suspicion. The
association of macrocephaly and angiomatosis may occur in disseminated haemangiomatosis, neurofibromatosis, Beckwith-Wiedemann syndrome, Klippel-Trenaunay-Weber syndrome and cutis marmorata telangiectatica congenita.

**Treatment**

Satisfactory treatment of the patient with a port-wine stain has escaped all investigators (Thomson, 1979). Various modalities of treatment have been tried, but all have failed the patients' needs. These treatments include radiotherapy, cryotherapy, argon laser therapy and surgical tattooing. Cosmetic camouflage remains the mainstay of treatment. However, surgical tattooing may enable the patient to use a lighter cosmetic coverage, but fading or leaking out of the pigment is the major drawback; such fading appears less in adult patients. Seizures are managed using standard anticonvulsant therapy.

**Lymphangioma**

About 75% of cases of lymphangioma are found in the head and neck region. Like haemangiomata, these hamartomata are almost always evident by the age of 3 years. They may be present as unilocular or multilocular (more common) masses, with thin, often transparent walls enclosing a straw-coloured fluid. Such lesions are known as *cystic hygromata*.

Cystic hygromata are usually slow-growing, unless there is an associated internal venous haemorrhage or infective lymphangitis. Most lesions appear in the posterior triangle of the neck, often occupying the supraclavicular fossa. When they occur in the submandibular region or in the cervical prevertebral region, there may be severe respiratory distress in the neonatal period, especially if the disease is bilateral.

On rare occasions there is a rapid increase in growth. This can result in a grotesque enlargement of the affected side of the face, with the eye becoming obscured and gross distortion of the mouth. Hypertrophy of the maxilla and mandible may develop, but not to any marked extent.

There appears to be considerable disagreement about whether or not these lesions undergo spontaneous regression.

**Treatment**

This condition responds poorly to both radiotherapy and cryotherapy. Apart from the long-term danger of irradiating the neck in a child, radiotherapy produces extensive fibrosis, and this renders subsequent surgical dissection extremely difficult. Similar difficulty is experienced following the injection of sclerosing fluids. Thus radiotherapy, cryotherapy and sclerosing fluids should be avoided in the management of lymphangiomata.

Surgery remains the mainstay of treatment. Lymphangiomata of the neck and upper mediastinum which produce neonatal respiratory distress require to be treated as acute surgical emergencies. A preoperative chest radiograph is mandatory in order to exclude mediastinal extension. A tracheostomy and wide surgical excision is the treatment of choice. Cystic
hygroma has an apparent disregard for anatomical planes, making total excision very difficult, and sometimes impossible. For this reason, some surgeons prefer less radical means of surgical decompression, employing vacuum drains or marsupialization of the cysts (Thomson, 1979).

In gross cases, a radical approach should be made without regard for the facial nerve (Mustardé, 1979). Not only is it extremely difficult to dissect out the functioning branches of the nerve, but more importantly, gross involvement and stretching of the facial muscles renders their preservation pointless and usually impossible. A series of planned resections is necessary, and subsequent reconstruction involves the standard techniques for dealing with facial palsy. Readers are directed to Mustardé's account for information regarding management of grossly involved eyelids.

**Benign neoplasms**

**Neurofibroma**

This benign tumour of the nerve sheath is an important, if rare, cause of gross facial deformity. It occurs only rarely as a solitary tumour. Much more often there are multiple tumours (neurofibromatosis) occurring in connection with the nerves of the skin and subcutaneous tissues and also those of internal organs. Neurofibromatosis (von Recklinghausen's disease) is an hereditary disorder transmitted as an autosomal dominant trait. It has the highest mutation rate known to man, 50% of cases representing a fresh mutation. The commonest presentation of this disease to the surgeon is that of facial deformity, and on rare occasions this may result in a gigantic overgrowth of one side of the face. While café-au-lait skin pigmentation may have been present since birth or early childhood, tumour formation becomes evident during childhood, and is usually most aggressive at the time of puberty. The condition is progressive, not subject to spontaneous regression, and the pathology is that of plexiform neurofibroma. Both the fifth and seventh cranial nerves are involved, and it is impossible to dissect them out from the mass of tumour tissue. In gross facial lesions the facial bones are involved, and may show considerable enlargement and deformity. The skin is grossly expanded, and may hang down in tumour-filled folds over the eye or cheek; the eyelids may be considerably elongated.

**Differential diagnosis**

A gigantic plexiform neurofibroma of the face bears a resemblance to gross haemangiomata and lymphangiomata, but is usually distinguished by the simultaneous presence of café-au-lait spots. Polyostotic fibrous dysplasia with grossly enlarged facial bones may also have café-au-lait patches, but the enlargement is bony rather than soft tissue. Hemifacial hypertrophy is an enlargement of all the elements of the face, and this should make it easy to distinguish from neurofibroma.

**Treatment**

Treatment is directed at serial resection, access being gained via an extended parotidectomy incision, with secondary incisions in the nasolabial folds and eyelid margins. No attempt is made to preserve neurological function, and excess skin should be excised. The
neurofibromatous tissue is extremely vascular, but preliminary carotid ligation does not usually result in a significant reduction in peroperative bleeding. Complete removal of all the involved tissue is virtually impossible. Resection of grossly involved parts of the maxilla and mandible may be necessary. There is considerable skeletal deformity in the orbital region; surgery is, of necessity, crude, and enucleation of the globe may be required.

Prodigious efforts are usually expended over a number of years to effect an improvement in appearance, but this is seldom acceptable to the patient or his relatives. The prognosis is poor, as growth of the incompletely excised tumour tissue is unavoidable. In addition, there is the risk of malignant transformation.

**Miscellaneous malformations**

*Congenital hemihypertrophy of the face (facial gigantism)*

Asymmetrical growth or development of the body or any of its parts is not too unusual; this may be trivial or very obvious. It may result from localized overgrowth of a single tissue or of all the tissues within a part.

Marked asymmetry caused by localized overgrowth of all the tissues within a part is rare. It is probably due to faulty cell division of the zygote which results in two daughter cells of unequal size, and has been considered a form of incomplete twinning (Norman, 1983).

Congenital hemihypertrophy may be of several types, and these have been classified by Rowe (1962):

1. complex hemihypertrophy involving an entire half of the body, or at least an arm and a leg; enlarged parts may be all on the same side of the body (complex ipsilateral hemihypertrophy) or crossed, in which case enlarged parts may be found on both sides (complex contralateral hemihypertrophy)

2. simple hemihypertrophy, involving part of the whole of a limb

3. facial hypertrophy, involving one side of the face.

The criteria for the hemifacial type of congenital hypertrophy are as follows:

1. unilateral enlargement of the viscerocranium bounded superiorly by the frontal bone (not including the eye), inferiorly by the inferior border of the mandible, medially by the facial midline and laterally by the ear, the pinna being involved

2. enlargement of *all* tissues - bone, teeth and soft tissue - within this area.

Almost all instances of this condition are sporadic, but a few familial cases have been reported. The incidence is about one per 15,000 births. Rowe (1962) recorded that the enlargement results from an increased number of cells rather than increase in cell size.
Asymmetry is usually evident at birth, but may become accentuated with age, especially at puberty. Occasionally there is unilateral enlargement of a cerebral hemisphere, and mental retardation is reported in 15-20% of cases. When the hemihypertrophy is restricted to the face, there is usually macroglossia. The lips, palate, maxilla and dentition (especially the permanent teeth) are all enlarged. Unlike both hard and soft tissues, the teeth are unique in that their form and size are determined early and thereafter are not modified. A consideration of the size of the teeth on the affected side, therefore, is significant in this condition, as it establishes it as being congenital. Of special interest is the association with various neoplasms, such as adrenocortical carcinoma, nephroblastoma, hepatoblastoma, adrenal adenoma, adrenal neuroblastoma and undifferentiated sarcoma of the lung. Neoplasia and renal dysplasia may be the cause of a reduced life span.

**Differential diagnosis**

Congenital facial hemihypertrophy may be confused with lymphangioma, haemangioma, neurofibroma and lipoma. It is usually distinctive due to involvement of all the tissues in the region, and it is the only condition where the teeth are enlarged.

**Treatment**

Due to the involvement of all facial tissues, surgical correction can be difficult, and as a result of the extreme paucity of cases, few surgeons gain much experience in treating such patients.

**Progressive hemifacial atrophy**

This disorder is also called Romberg's disease, Parry-Romberg syndrome and progressive facial hemiatrophy. Although it was mentioned by Parry in 1925 (Gorlin, Pindborg and Cohen, 1976), credit for its description is usually given to Romberg (1846). The condition consists of:

1. slowly progressive atrophy of the soft tissues of essentially half the face, accompanied most often by
2. contralateral Jacksonian epilepsy
3. trigeminal neuralgia
4. changes in the eyes and hair
5. associated atrophy of half the body.

Nearly all cases are sporadic, but a few familial cases have been noted. There is no proven cause for progressive hemifacial atrophy. After a review of the various hypotheses, Rogers (1977) has concluded that a sympathetic nervous system cause is the most likely. It is postulated that sympathetic tracts are affected centrally, perhaps directly in their centres in the diencephalon. There is a long-standing debate about the relationship between progressive and hemifacial atrophy and scleroderma, some
authors asserting that the *coup-de-sabre* form of scleroderma is a special type of progressive hemifacial atrophy.

**Clinical features**

Progressive hemifacial atrophy classically starts during the first decade with atrophy of the subcutaneous fat in the paramedian area of the face. The process slowly spreads, so that atrophy of the underlying muscle, bone and cartilage becomes apparent. From the initial site, frequently in the area covered by temporalis and buccinator muscles, involvement extends to include the brow, angle of the mouth, neck or even half the body. There is a marked predilection for left-sided involvement, and the overlying skin often becomes darkly pigmented. Changes in the hair may precede those in the skin; the scalp on the affected side may exhibit complete alopecia limited to the paramedian area, eyelashes and medial part of the eyebrow. Poliosis (blanching of the hair) has been observed.

Loss of periorbital fat produces enophthalmos and the outer canthus may be displayed due to loss of the underlying bone. Muscular paresis, lagophthalmos and ptosis have all been reported, as well as a variety of inflammatory, intraocular conditions.

The bone and cartilage of the face are underdeveloped to a degree directly related to the age of onset of progressive hemifacial atrophy. The bony involvement is thus most severe when the disorder commences in early childhood. When the mandible is involved, both ramus and body are shorter than the contralateral side, and teeth on the involved side may be retarded in eruption or may have atrophic roots. Atrophy of half the tongue and upper lip are common, sometimes resulting in exposure of the teeth.

The commonest neurological abnormality is epilepsy, usually of the Jacksonian variety, which often appears late. Conversely, trigeminal neuralgia and/or facial paraesthesia appear early, and may precede the rest of the changes. Migraine is a common finding.

Progressive hemifacial atrophy usually commences in late childhood or adolescence, and 75% of cases appear before the twentieth year. The atrophy is slowly progressive, and is usually limited to one side of the face, although bilateral disease has been reported. The ‘active’ period of the disease progression lasts for 2 to 10 years, but may stop at any time, leaving minimal deformity. Some cases of progressive hemifacial atrophy continue beyond a period of 10 years.

**Differential diagnosis**

The main conditions with which progressive hemifacial atrophy may be confused are scleroderma and craniofacial microsomia.

**Treatment**

Little information is published about the treatment of this condition, and the results are frequently disappointing. The main problem is that the same unknown factors which cause the initial atrophy frequently act against the success of the various forms of graft that have been used in reconstructive surgery; this is clearly a major problem when surgical procedures
are undertaken during the 'active' phase of the disease. If at all possible, treatment is better delayed until the atrophy is no longer progressive.

**Dimetrylpolysiloxane fluid injections**

This liquid form of silicone has been widely used in the USA, and is advocated by Grabb (1979) as the best treatment for progressive hemifacial atrophy. Plastic surgeons in the UK, however, have found this method of treatment less satisfactory. Inflammatory reactions, excessive fibrosis and migration of the fluid have all caused problems, and the technique has largely been.

**Grafts**

Dermo-fat grafts are still widely used. When they are inserted in areas not affected by progressive hemifacial atrophy, the resorption rate is unpredictable, and 50% or more of the original bulk is often lost. The resorption rate of dermo-fat grafts in tissues affected by the atrophy is even greater, and patients with severe forms of the disease have to be regrafted many times.

**Flaps**

Pedicled flaps of omentum have been used, but if this tissue is chosen, it is now more frequently used as a 'free' microvascular transfer. Temporalis muscle has been transferred on its pedicle in cases where the upper face has been largely spared, but this technique is clearly unsatisfactory in patients with extensive and severe involvement of the face.

The recent development of microvascular techniques has offered the best chance for reconstruction in progressive hemifacial atrophy. Each microvascular surgeon has his own preference in selecting the donor site. The main problems are the maintenance of an even distribution of soft tissue so transferred (it frequently 'sags') and variation in the bulk of the flap with changes in the weight of the patient due to its content of adipose tissue.

**Moebius syndrome**

This condition, while rare, is one of the commoner disorders of oromandibular limb hypogenesis. Moebius (1888), in attempting to classify multiple congenital cranial nerve palsies, created a division in which palsies of the sixth and seventh cranial nerves were combined. Subsequently the concept nerves were combined. Subsequently the concept of Moebius syndrome has been expanded to include:

- sixth and seventh cranial nerve palsies, usually bilateral
- occasionally other cranial nerve involvement (third, fifth, ninth and twelfth)
- reductive limb anomalies (30%)
- Poland anomaly (15%) ie abnormality of pectoralis major muscle and ipsilateral syndactyly
- mild mental retardation (10-15%).
The aetiology of Moebius syndrome is unknown, and all cases are sporadic. Post-mortem studies have demonstrated nuclear agenesis.

**Clinical features**

The mask-like facies is characteristic. Bilateral facial palsies usually important a symmetrical appearance, but variation in the degree of involvement of each side of the face can cause significant asymmetry. Occasionally the facial palsy is unilateral.

Most patients cannot abduct either eye beyond the midline, but unilateral sixth nerve palsy does occur. Ptosis, nystagmus or strabismus may accompany the above features, and epicanthal folds are common. Some patients are unable to close their eyelids, resulting in conjunctivitis or corneal ulceration.

The nasal bridge is often high and broad, especially during infancy and childhood. The broadness of the bridge extends downwards in a parallel fashion to include the nasal tip, thus providing midfacial prominence which is accentuated by the retruded mandible.

The angles of the mouth droop, allowing saliva to escape. The mouth aperture is small, and mandibular opening may be restricted; this tends to improve spontaneously as the child develops. Unilateral or bilateral tongue hypoplasia is seen, and when combined with poor palatal mobility, can result in impaired feeding or speech. The mandible is frequently hypoplastic, adding to these problems. The pinnas may be hypoplastic, normal or large, and frequently protrude laterally.

Unilateral, bilateral or asymmetrical hypoplasia or aplasia of pectoralis major muscle or complete Poland anomaly occurs in 15% of cases. Limb defects occur in 50% of cases. Limb defects occur in 50% of affected individuals, 30% constituting talipes deformities and the other 20% include hypoplasia of digits, syndactyly or more severe reductive deformities. Mental retardation, usually of a mild nature, occurs in 10-15% of patients with Moebius syndrome.

**Differential diagnosis**

There are variable degrees of overlap between the oromandibular limb hypogenesis syndromes. Thus Moebius syndrome must be distinguished from Charlie M. syndrome, glossopalatine ankylosis syndrome, Hanhart syndrome and hypoglossia-hypodactilia syndrome; all these are much rarer than Moebius syndrome. Similar limb defects are seen in the Poland anomaly, amniotic band syndrome and other reductive limb anomalies.

Superficially, Moebius syndrome may be confused with craniofacial microsomia, Treacher Collins syndrome and Pierre Robin syndrome. Isolated facial palsy may occur as an inherited disorder, or may result from birth trauma.

**Treatment**

The treatment of Moebius syndrome has received scant attention. Much has, however, been written about the management of facial palsy. It is outside the scope of this chapter to
cover this challenging field of reconstructive surgery. Static sling procedures and reanimation techniques each have their advocates. It is the author's experience that results of reanimation are inconsistent and often disappointing, although satisfactory results are occasionally presented. If advances in this field are to continue, it is essential that patients with facial palsy are referred to those surgeons with an interest in and experience of these problems.

If static slings are employed, it is preferable that they are delayed until after any orthognathic surgery has been performed, as they usually severely restricted access to the oral cavity. The same principle applies to orthodontic treatment which is usually necessary.

The upper lip is short and immobile. The only satisfactory way of managing this problem is by means of a Le Fort I osteotomy to intrude the maxilla. This will have to be accompanied by an osteotomy of the mandible which usually needs advancement. Surgical details of the various orthognathic techniques are well described by Henderson (1985). Repositioning of the jaws may have a beneficial effect on feeding and speech, although the results are frequently disappointing in this respect.

The facial appearance can be further improved by correcting the wide nasal bridge and epicanthal folds when present.