The surgical treatment of noma

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The surgical treatment of noma

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To all our patients at Noma Children Hospital, Sokoto, Nigeria

Contents

Foreword

This book is aimed at surgeons and anaesthetists who see the needs of patients suffering from the sequelae of noma, and are working in developing countries or are planning to do so on a permanent basis or as part of a surgical aid programme.

Reconstructive surgery to alleviate the sequelae of noma can be performed in many different ways, depending on the skills and experience of the medical personnel and the facilities available on site. The authors, and all those who have helped in the formulation of the guidelines given here, are experienced plastic and maxillofacial surgeons and anaesthetists accustomed to the blessings of well-equipped hospitals and multidisciplinary treatment groups. They also have vast experience of working under more challenging conditions in Africa and Asia. In particular, the experience of the difficult techniques of facial reconstructive surgery in noma patients gained during hundreds of operations at the Noma Children Hospital in Sokoto, Nigeria, has been essential for the writing of this book.

The treatment protocol outlined here should suit most surgeons who intend to treat noma patients. It is based on the fundamental tenets of noma surgery as laid down nearly forty years ago by the British plastic surgeon Michael Tempest – who stated that the methods of repair used should be safe, simple, sound and satisfactory – and is further enriched by the many innovations brought about in facial reconstructive surgery since then.

We hope that the effort put into the preparation of this book will contribute to a major expansion of the services offered worldwide to the sufferers from this age-old scourge of mankind.

Kurt Bos
Klaas Marck

Introduction 1

History

Famine is an old companion of mankind. One of the many ways hunger battens on human life is noma: an overwhelming invasion of micro-organisms from the oral orifice into the face leading to gangrene, sepsis and death. Noma attacks people, particularly children, who are weakened by malnutrition and infectious diseases such as measles.

A compilation of the medical history of noma has recently been published (Marck, 2003a, 2003b).

Noma already appears in the writings of classical medical authors as Galenus and Celsus. They described quickly spreading oral ulcers in children, often with a fatal outcome. The first description of noma as clinical entity dates from 1595, when Carolus Battus, a refugee from Antwerp who had settled in the Netherlands, wrote a chapter on 'watercancker' (as it was called in Dutch at the time) in his *Handboeck der Chirurgijen* (Surgeons' Handbook).

In 1680, Cornelis van de Voorde introduced the term 'noma' for orofacial gangrene in children. He wanted to avoid the word 'watercancker', since he was convinced that this condition was due not to a cancerous growth but to an infection. The word *noma* is an ancient Greek word that means 'meadow', 'grazing', and in a metaphorical sense also 'a quickly spreading sore'.

Noma was common in Europe and the United States in previous centuries (Fig. 1.1). The first successful attempts to reconstruct faces ravaged by noma date from the end of the eighteenth century, while by the mid-nineteenth century the medical literature includes accounts of extensive facial reconstructions in patients who had survived noma, especially by German authors. Noma disappeared from the developed world about a century ago, when even the poorest members of society were able to feed their children sufficiently. It reappeared in Europe during World War II (1939-45) however, in concentration camps and in countries like the Netherlands subject to extreme food shortage during part of the war (Fig. 1.2).

FIGURE 1.1 *Noma was common in Europe in previous centuries. The illustration dates from 1844 and shows a striking similarity with a recent clinical picture (see also page 32, Fig. 3.26 (right)).*

FIGURE 1.2 *Noma reappeared in Europe during World War II (1939-45).*

The fundamentals of facial reconstructive surgery for the sequelae of noma were developed by Michael Tempest, a British plastic surgeon who worked in Nigeria in the 1960s. He outlined the basic principles of this challenging but extremely rewarding surgery in his classic paper *Cancrum oris* (Tempest, 1966). Since then few facial reconstructive surgeons have shown any interest in this difficult part of their specialty. The exceptions that prove the rule include Adekeye (Adekeye, 1983; Adekeye and Ord, 1983; Adekeye et al., 1986) from Nigeria and Montandon from Geneva (Montandon et al., 1991, 1996), who inspired a growing number of reconstructive surgeons to dedicate a good part of their capabilities to the development of a strategy for the surgical rehabilitation of noma patients during the last decade.

Epidemiology

A society starts to count its dead citizens only when it is able to feed its living. It follows that no exact figures are available for the annual incidence of noma worldwide, since the countries where this condition is widely found are those where poverty reigns and measles epidemics are common, and where civil administration is insufficiently well developed to maintain reliable health statistics.

The World Health Organization estimated in its World Health Report for 1998 that the global incidence of noma amounts to 140 000 patients, and that 770 000 patients who survived noma in the past are currently suffering its sequelae (Bourgeois and Leclercq, 1999).

These figures may be dated. Well-founded recent estimates of the incidence of noma in Sokoto State, Nigeria, indicate that the incidence of noma is 6.4 per 1000 children in Northwest Nigeria. Extrapolation of this figure to the developing countries bordering the Sahara Desert (the 'noma belt' of the world) yields an estimated incidence of around 25 000 for that region and a global incidence of 30 000-40 000 (Fieger et al., 2003).

Reliable data on the mortality from noma do not exist. Based on scarce and mainly historical information, we estimate it to be about 90%.

This means that 3000-4000 noma patients, mainly children, are likely to survive this affection every year. With an average life expectancy of 36 years (another estimate) the total number of noma survivors in the world today may be estimated to be about 100 000.

The distribution of noma over the world is uncertain. It is assumed that most noma patients live in the sub-Saharan countries of Mauritania, Senegal, Mali, Niger, Nigeria, Chad, Sudan and Ethiopia (the 'noma belt'). Incidental cases are reported from many other parts of Africa and some Asian and Latin American countries (Bourgeois and Leclercq, 1999).

According to Tempest the vast majority of patients contracting noma are 1, 2 or 3 years old. Some are in the 4-10-year age-group, while only a few are older. These figures agree well with the age distribution of noma deaths in the Netherlands in the nineteenth century (Marck, 2003a).

Aetiology and pathogenesis

Noma is called 'the face of poverty' because poverty is directly related to its occurrence. Malnutrition is the major predisposing factor for this condition (Fig. 1.3), while debilitation due to concomitant disease (in particular measles but also malaria, tuberculosis, typhus, HIV and other infections) and poor oral hygiene (in particular the presence of acute necrotizing gingivitis) also play a contributory role (Fig. 1.4).

Malnutrition and debilitation due to disease weaken the patient's immune system. If at the same time there is a high bacterial load in the mouth caused e.g. by acute necrotizing gingivitis, the organism may be unable to resist an overwhelming invasion of oral micro-organisms. If this leads to gangrene of facial tissue, the clinical picture of noma has arrived. The overall pathogenesis with special reference to biochemical and immunological parameters has been worked out in detail by Enwonwu (Enwonwu et al., 1999a, 1999b).

Many early bacteriologists suggested the presence of a '*bacillus nomae*'. It became clear during the first half of the twentieth century however, that noma is not caused by a specific pathogen. Both a spirochete and a fusiform microorganism can be observed in the transitional zone between the rapidly expanding gangrene and healthy facial tissue. These were previously identified as *Fusiformis fusiformis* and *Borrelia vincenti*; the former is currently known as *Fusobacterium nucleatum*, while the latter is an unidentified spirochete nowadays. Both are part of the normal oral flora (Emslie, 1963). This implies that noma should be considered an opportunistic infection. Noma has not received much attention from research microbiologists during the past century. Here lies a challenge for modern medical microbiology, with its sophisticated techniques, to identify the microbiological pathways leading to this devastating gangrene.

The early stages of noma are characterized by swelling of the cheek and/or lip, excessive salivation, a horrible *foetor ex ore* and pain. Inspection of the oral cavity may reveal a darkish coloured spot or ulcus in the gingiva or the mucosa of the cheek or lip.

FIGURE 1.3 *Noma is related to poverty and chronic malnutrition.*

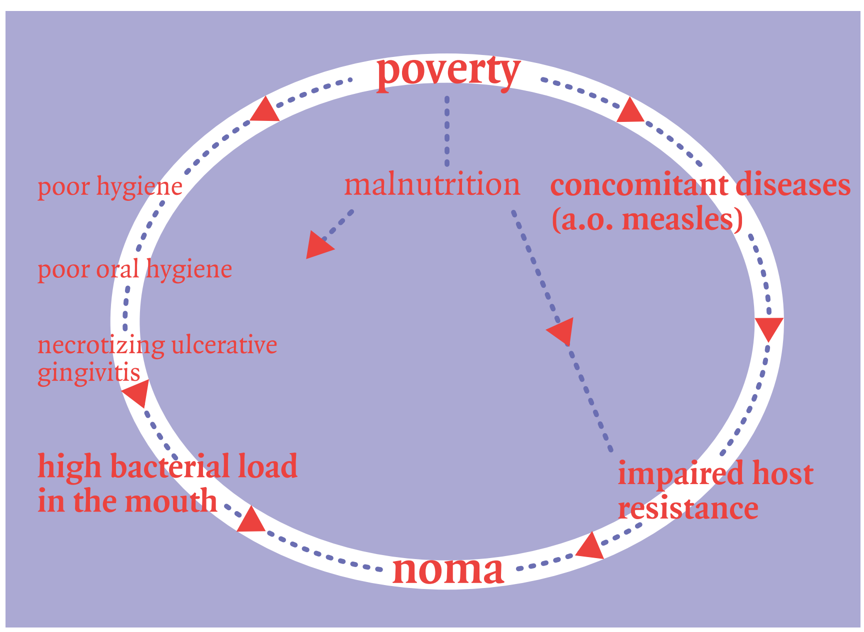

FIGURE 1.4 *Schematic representation of the factors responsible for the development of noma.*

Within a few days the skin of the cheek or lip discolours lividly, the gingiva and the mucosa reveal extensive slough and the mouth becomes even more foul-smelling. Teeth and molars become loose.

The skin of the cheek or lip is typically perforated within a week of the start of the swelling. This full-thickness gangrene of the facial tissue quickly spreads to other parts of the face such as the contralateral side, the palate, the nose or an eye. Almost all patients will have succumbed to sepsis by this stage.

The expansion of the gangrene may be halted at any stage if the patient's constitution is sufficiently resistant. If the patient is also able to overcome secondary infections and the risks of subsequent sepsis, necrotic soft tissue will be sloughed and necrotic bone subsequently sequestered. Long-term repair mechanisms may then become activated. Granulation tissue appears, wound contracture begins and epithelium and mucosa grow to cover the granulating wounds. Without any treatment an estimated 90% of patients die. Adequate treatment which is relatively simple and inexpensive (administration of antibiotics, rehydration, feeding and treatment of concomitant diseases) can cause the mortality to drop to approximately 20% (Tempest, 1966).

Differential diagnosis

The pithy words of Mead – 'there is nothing else like it' – are often cited to suggest that the clinical diagnosis of noma is easy and certain (Tempest, 1966). In many patients this is true. A medical history of a recent childhood illness, facial swelling and a foul-smelling discharge from the mouth in a malnourished child form a strong indication of the presence of the first stage of noma. The development of facial gangrene a few days later will remove all traces of doubt.

If, however, an older patient presents with a mutilated face and a no clear history of previous illness, other etiologies should also be considered (Enwonwu et al., 1999b). The mutilation may be the result of a trauma (human or animal bites may result in severe lip and nose deformities) or traditional healing methods (cauterizing iron, necrotizing herbs). Various infectious conditions such as yaws, gangosa, syphilis, leprosy, Buruli ulcer (Asiedu et al., 2000) and midline granuloma may also result in facial deformities that bear a certain resemblance to noma. These conditions rarely or never occur in young children, however.

The World Health Organization strategy against noma

2

Historical background

Over the past decade, noma has received increasing attention from the international community and has been recognized as a major public health problem by the World Health Organization (WHO). Awareness has been raised in particular by warnings from the governments of several countries, and various NGOs, about the recrudescence of noma in the developing world, mainly in sub-Saharan Africa. The increasing number of cases reported show that noma cannot be dismissed as a scourge of previous centuries, but remains a public health issue in the poorest communities of the world, and still claims thousands of victims every year.

Given this alarming situation, the fight against noma has become a priority for the WHO. In 1989, it organized the first information session on noma at the World Health Assembly, and in 1992 it developed the outlines of an action plan against the disease in close cooperation with several West African countries and NGOs. This resulted in the inclusion of a five-point strategy in the WHO International Action Program against Noma adopted in 1994 (Bourgeois and Leclercq, 1999).

The five overlapping elements of this strategy are as follows:

- Epidemiology and surveillance.
- Etiological research.
- Prevention.
- Primary health care.
- Surgical rehabilitation.

These are discussed in turn below.

Epidemiology and surveillance

Formerly described in Europe and North America, most noma cases are reported now in the developing countries of Africa, Asia and South America. Most recent reports come from impoverished, famine-stricken African nations (Barmes et al., 1997; Enwonwu, 1995).

According to WHO estimates, there are about 100 000 new cases of noma every year, with fatality rates of approximately 80% in the absence of treatment (World Health Report, 1998).

When the WHO map (Fig. 2.1) showing the global distribution of noma was updated in 2000, several striking observations emerged:

- The disease continues to be a worldwide problem.
- Africa remains the hardest hit continent.
- Sporadic cases occur in developed countries, where its re-emergence seems to be linked to determinant factors such as AIDS.
- The absence of reliable data hampers effective action in certain developing countries, including some in Africa.

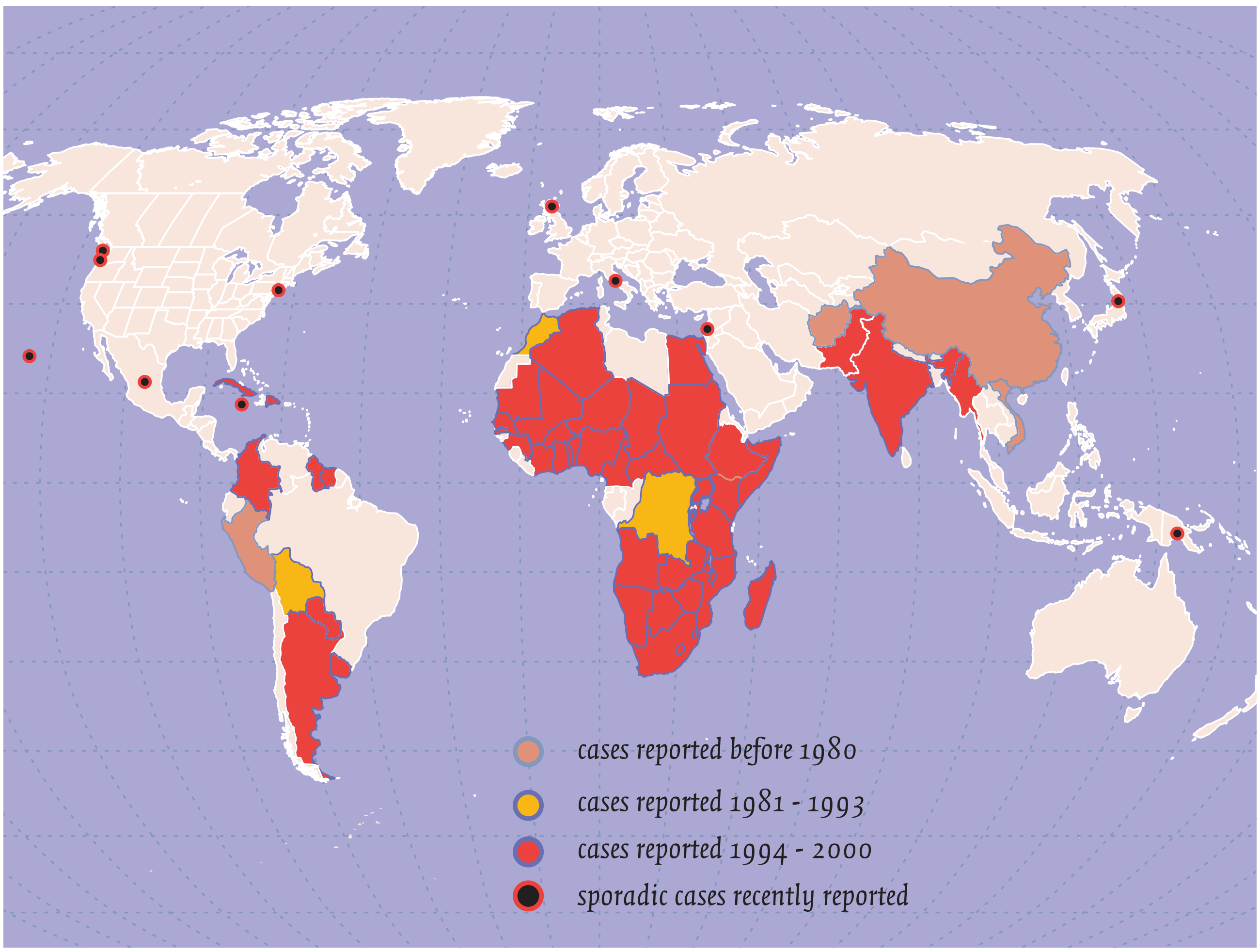

FIGURE 2.1 *Global distribution of noma.*

Reliable information on the magnitude of the problem is not always available, mainly due to the diversity of information sources and variations in methodological approach. Existing data are generally derived from patients' files and records of the activities of NGOs (Barmes et al., 1999; Leclercq et al., 1999), supplemented by case reports and surveys in some countries (Ndiaye et al., 1999).

In order to standardize data collection at country level, during the 1990s the WHO developed tools for epidemiological studies on referred cases and national retrospective surveys of orofacial mutilations and noma.

The WHO also recommends including noma in existing epidemiological surveillance systems.

Etiological research

Since the beginning of the last century, numerous hypotheses have been put forward to explain the etiology of noma, and several avenues of research have been followed (Weaver and Tunnicliff, 1907; Tempest, 1966). To date, however, there is no consensus on the responsible agent – though it is widely suspected to be infectious.

Nevertheless, the association between the following factors and noma is well documented and uncontroversial: poverty, inadequate environmental sanitation, malnutrition, poor oral hygiene, predisposing infectious diseases such as measles, and lack of general hygiene.

Research on the etiology of noma was improved in the 1990s. International community efforts to eliminate the disease also resulted in collaborative studies. Notably, the International Collaborative Research Project on Orofacial Gangrene was jointly developed by the WHO, the University of Maryland (Baltimore, USA) and the US National Institute of Dental and Craniofacial Research with the aim of studying the etiology of noma, particularly its nutritional and microbiological aspects.

Prevention

Prevention has a high priority in the WHO strategy against noma. Noma is an easily preventable disease. Efforts to raise awareness of it, and in particular to educate and inform mothers and caregivers about the signs to look out for and the urgent need to take action, should be integrated into existing health education and promotion activities, like those aimed at improving nutrition and promoting the integrated management of childhood illnesses and the expanded immunization programme.

Prevention also involves training primary health care workers in the early detection of noma and provision of immediate care.

Primary health care

'Any child with a mouth ulcer living in poor circumstances, such as one who is malnourished, immuno-compromised, recovering from measles and living under poor sanitation, should be regarded as a potential noma case' (WHO, 2001).

Diagnosis of noma is often made on clinical grounds. If it is detected and recognized at an early stage, simple, effective, low-cost care can be provided. Local disinfection, administration of appropriate antibiotics and nutritional supplementation have all been shown to prevent progression from initial ulceration to the acute gangrenous phase.

In order to improve early detection of noma cases and facilitate provision of immediate care, the WHO has published a leaflet describing the progress of noma from necrotizing gingivitis to the loss of tissue (WHO, 1994). It is illustrated with colour photographs and suitable for use by non-specifically trained health workers in primary health care centres and community health programmes.

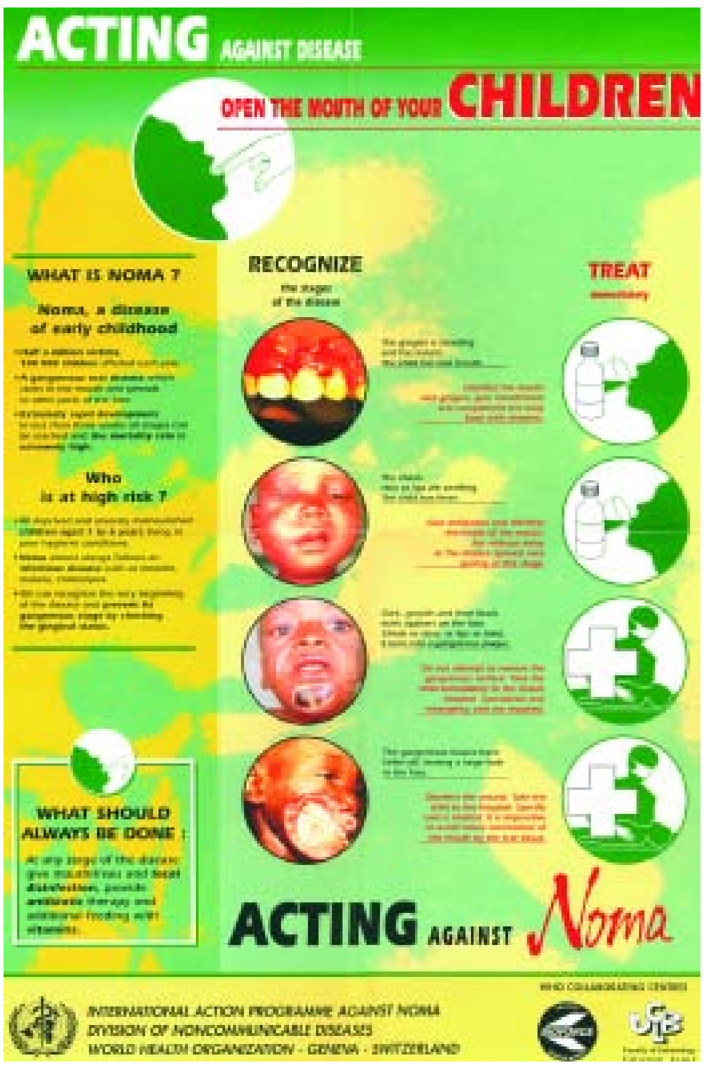

FIGURE 2.2 *Posters are used to promote early detection of noma.*

Another WHO campaign, *'Acting against disease, open the mouths of your children'*, is also intended to promote early detection of noma and immediate care for patients. It involves large scale distribution (within Member States) of illustrated posters to help health professionals and community health workers recognize each stage of the disease, provide adequate treatment, and/or refer the patient (Fig. 2.2).

Noma evolves very rapidly and the early stages are difficult to diagnose. The WHO encourages integration of noma into existing health services, particularly at primary care level, and recommends that all district health personnel be trained in its recognition, management and referral.

Surgical rehabilitation

Noma survivors left with deformities need plastic and reconstructive surgery. Because access to complex surgical care is limited in Africa, children are generally referred to facilities in the industrialized world or, in some countries, are treated locally by teams of Western surgeons. Such missions also provide an opportunity to train local health care workers.

In 2001, the WHO consultative meeting on noma recommended that the Noma Children Hospital in Sokoto, Nigeria, should receive additional resources and be designated the Regional Referral Centre for the management of noma cases and the training of personnel from other countries in the region.

The Noma Program of the WHO African Region

Noma was recognized as a priority disease in the WHO African Region in 1998, at the 48th session of the Regional Committee, Harare (Zimbabwe) (Resolution AF/RC48/R5).

Following a decision of the Regional Consultative Committee in 2000, the Noma Program activities were transferred from WHO headquarters in Geneva to the WHO Regional Office for Africa.

The Noma Program of the African Region was launched in 2001 with the aim of eradicating noma. Since then, progress has been made in the fight against the disease, and a large network of coordinated activities covering each of the five elements of the strategy described above has been established in many African countries, including Angola, Benin, Burkina Faso, Mali, Niger, Nigeria, Lesotho and Zambia.

Conclusion

Over the past decade, the international community has made substantial advances in the fight against noma. Several years of active promotion resulted in growing interest worldwide, and noma is now receiving much more attention than before from policymakers, researchers, health professionals and the general public. However, we still have many obstacles to overcome and many challenges to address as we progress towards elimination of this life-threatening childhood health condition.

As we enter the 21st century, there is an opportunity to ensure that noma is never again 'the face of poverty'. Achieving that goal will require multidisciplinary, multisectorial and multinational action to combat the effects of poverty; more specifically, we will need to strengthen political commitment, mobilize resources, and promote international collaboration.

Classification of tissue defects in noma

3

Introduction

A classification is not an end in itself but should help us to organize our observations, structure our choice of treatment and evaluate the clinical outcome.

The variety of facial deformities encountered in noma patients is kaleidoscopic. The extent and site of the tissue defects vary enormously, and no two patients are the same. Several surgeons have responded to the challenge of bringing order into this facial chaos on the basis of the large series of noma patients they have seen. A number of classifications have been proposed over the past half century, mainly by French-speaking surgeons (Reynaud et al., 1961; Cariou, 1986; Montandon et al., 1991). The most comprehensive is the descriptive classification put forward by Cariou, which makes use of illustrations of typical defects as a basis of comparison.

The semiquantative classification method described in this chapter was developed at the Noma Children Hospital in Sokoto, Nigeria. It allows noma defects to be classified by dividing the face into a number of anatomical units, estimating the extent of tissue loss in each unit as accurately as possible and considering other relevant factors. It is known as the **NOITULP** classification, for reasons that will become apparent below.

This classification serves several purposes:

- It compels the surgeon to carry out a thorough, systematic examination of the patient's face.
- It helps to imagine the extent of the defect before scar contraction reduced its size and deformed the surrounding face. As Tempest (1966) very succinctly put it, '*The surgeon must analyse carefully each problem and decide which tissues are missing and to what extent. He must train himself to recreate the original defect in his mind before he starts to do it with the knife*'.
- It supports the planning of the reconstructive procedures.
- It provides a basis for computerization of patient data and for comparison of the results of surgery with those in other patient groups.

FIGURE 3.1 *Discrepancy between the apparent extent of the tissue defect at the time of slough (left) and after wound contraction (right). Contraction of the soft tissues easily results in underestimation of the extent of tissue loss.*

There is a general tendency to underestimate the extent of the tissue loss in noma, due to the huge forces of contraction that play a role in the healing of soft tissues like lips and cheeks. Figure 3.1 shows the original tissue defect in one patient at the time of slough and the result of the unaided healing process (see also page 35, Fig. 4.1 and page 39, Fig. 4.3).

Classification

In the present classification system, we determine the degree of tissue loss in the following anatomical units: nose (**N**), outer cheek (**O**), inner cheek (**I**), upper lip (**U**) and lower lip (**L**). The extent of trismus (**T**) is also noted, as are any other relevant particularities (**P**). Rearranging these initials gives the mnemonic NOITULP by which this classification has come to be known. The system is summarized in Table 3.1.

TABLE 3.1 **NOITULP classification**

N	=	nose
O	=	outer lining (of the cheek)
I	=	inner lining (of the cheek)
T	=	trismus
U	=	upper lip
L	=	lower lip
P	=	particularities

Of course, trismus is not an anatomical unit but a functional problem – the inability to open the mouth properly. It has been included in the system because of its clinical relevance (e.g. for intubation).

The extent of tissue loss in all anatomical units is scored from 0 up to 5 as shown in Table 3.2.

TABLE 3.2 **Quantification of tissue loss**

0	=	no loss
1	=	up to a quarter lost
2	=	from a quarter to a half lost
3	=	from a half to three-quarters lost
4	=	more than three-quarters lost

I Nose (N)

Pattern of nasal defects

- Almost all patients with a nasal defect also have a defect of the cheek and the upper lip. Furthermore, few patients with a nasal defect suffer damage to the pyriform aperture, the base of the nasal skeleton. These findings suggest that in most patients the nose is affected by spread of gangrene from the mouth, in line with the common observation of a scarred or deficient cheek and the absence of a lateral part of the nose.
- When patients have lost more than half of the nose, the septum is usually also lost and as a consequence presents a difficult reconstructive problem.
- No distinction is made between the inner and outer layers of the nose, because any attack on the nose destroys both these layers.

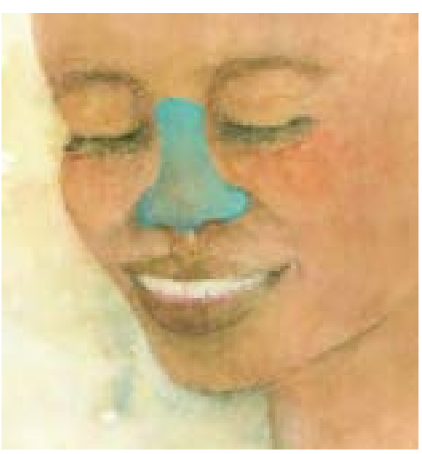

FIGURE 3.2 *Boundaries of the nasal unit.*

FIGURE 3.3 *Two examples of patients with a nasal defect classified as* **N**-1.

FIGURE 3.4 *Two examples of patients with a nasal defect classified as* **N**-2.

FIGURE 3.5 *Two examples of patients with a nasal defect classified as* **N**-3.

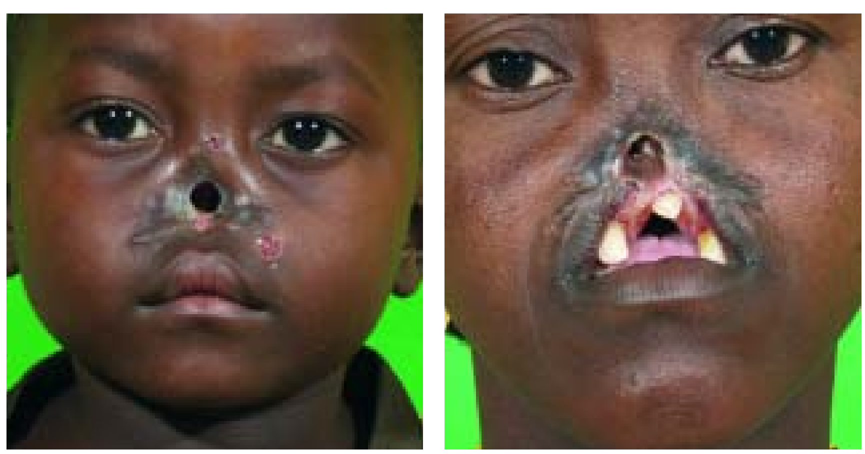

FIGURE 3.6 *Two examples of patients with a nasal defect classified as* **N**-4.

II Outer cheek (O)

Pattern of outer cheek defects

- The outer cheek is the most frequently affected area of the face. Most patients also present with a defect of the inner lining, and half with a severe trismus.
- The outer cheek is not uncommonly seen with a contracted and re-epithelialized scar.
- The extent of the outer and inner cheek defects will in general differ greatly, because the gangrene spreads from the inside to the outside.

FIGURE 3.7 *Boundaries of the outer cheek unit.*

FIGURE 3.8 *Two examples of patients with an outer cheek defect classified as* **O**-1.

FIGURE 3.9 *Two examples of patients with an outer cheek defect classified as* **O**-2.

FIGURE 3.10 *Two examples of patients with an outer cheek defect classified as* **O**-*3*.

FIGURE 3.11 *Two examples of patients with an outer cheek defect classified as* **O**-4 *(see also page 22, Fig. 3.1).*

III Inner cheek (I)

Estimation of inner cheek defects

To estimate the size of the inner-lining defect, ask the patient to open his mouth as far as possible. The mucosal trapezium formed by the upper and lower buccal sulci, the pterygomandibular raphe and the anterior border of the upper and lower lips can now be palpated. In a healthy adult, this trapezium has sides approximately 4 cm long and a surface area of about 12 cm^2.
As a rule of thumb, the surface area of a fingertip is about 1 $^1/_2$ cm^2 so that the investigator can place his fingertip in eight different places on the mucosa of the intact adult inner cheek.
In children, the smaller surface area of the inner cheek must be taken into account. Palpation with the tip of a little finger is usually advisable here.

In any case, the object of the palpation is to estimate what proportion of the lining of the inner cheek is still mucosa and has not been replaced by scar tissue or disappeared entirely. Once again, the extent of the defect can be scored as given in Table 3.2 (page 23) where mucosa replaced by scar tissue is also counted as 'lost'.

In all but the most extreme cases of trismus, it will still be possible to palpate the buccal mucosa at least with the little finger if not with the index finger. It goes without saying that the necessary adjustments will have to be made to the estimation of the area of intact mucosa in view of the smaller size of the fingertip used for palpation. If trismus is so severe that the investigator is unable to insert a finger for the purposes of palpation, it may be assumed that the loss of inner lining of the cheek is total.

This is probably the most difficult part of the examination and it may be subject to large inter-investigator variability.

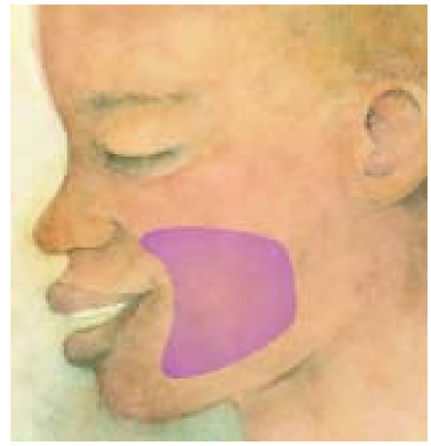

FIGURE 3.12 *Boundaries of the inner cheek defect.*

IV Trismus (T)

Pattern of the extent of trismus

- If the necrosis has not been extensive, a constrictive band may reduce the extent to which the mouth can be opened. This condition is known as *trismus capistratus*.
- If necrosis has been considerable, scar tissue may prevent any movement of the mandible. Trismus is usually caused by a dense scar in the posterior part of the inner lining just anterior to the temporomandibular joint.
- Complete trismus may sometimes be the result of an extraarticular bony fusion (*myositis ossificans*) between the mandible and the maxilla.

The extent of trismus is scored as given in Table 3.3.
This method of scoring trismus is a slight modification of that used in the NOITULP classification as initially published (Marck et al., 1998). The number of different degrees of trismus has been reduced, and the present scores correlate better with the clinical impact of the condition. The mouth opening is measured with a ruler or sliding callipers. It is defined as the distance between two fixed points on the anterior parts of the maxilla and the mandible, measured with the patient's mouth opened as far as possible, minus the corresponding value with the patient's mouth closed as far as possible. This is more accurate than simply measuring the distance between the teeth when the mouth is open.

The clinical relevance of determining the extent of trismus is twofold. Firstly, the finding of **T**-2 or **T**-3 indicates a considerable risk of intubation problems, which helps the anaesthetist in preparing for the operation. And secondly, **T**-2 and **T**-3 patients may have quite serious functional problems relating to feeding and speech.

TABLE 3.3 **Degree of trismus**

0	=	normal mouth opening: ≥ 40 mm
1	=	mouth opening 20 mm up to 40 mm
2	=	mouth opening > 0 mm up to 20 mm
3	=	no mouth opening = ankylosis

FIGURE 3.13 *A patient with trismus classified as* **T**-1*, opening his mouth.*

FIGURE 3.14 *A patient with trismus classified as* **T**-2*, opening his mouth. Note the 'anarchie dentaire'.*

FIGURE 3.15 *A patient with trismus classified as* **T**-3*, unable to open his mouth* *(see also page 54, Fig. 6.4).*

FIGURE 3.16 *Peroperative picture of a* **T**-3 *patient after trismus release. Only remnants of the mucosa are found on the mandible and maxilla (left). The pink shaded area shows the inner-lining defect (right).*

V Upper lip (U)

Pattern of defects of the upper lip

- Upper-lip defects are rather common: two-thirds of all noma patients have lost a part of their upper lip.
- The condition most frequently found is **U**-2, which implies that a quarter to a half of the upper lip is missing.
- The defect is generally localized at the corner of the mouth.
- At the corner of the mouth it is not uncommon to observe a concomitant defect of the lower lip.

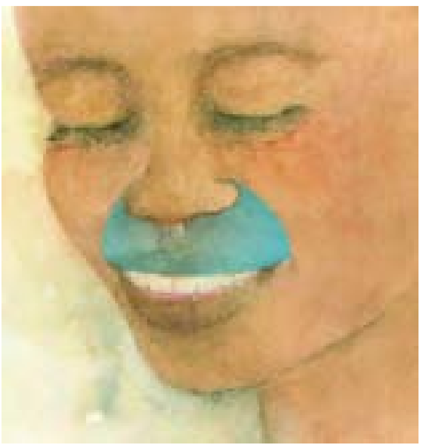

FIGURE 3.17 *Boundaries of the upper lip.*

FIGURE 3.18 *Two examples of patients with an upper-lip defect classified as* **U**-1.

FIGURE 3.19 *Two examples of patients with an upper-lip defect classified as* **U**-2.

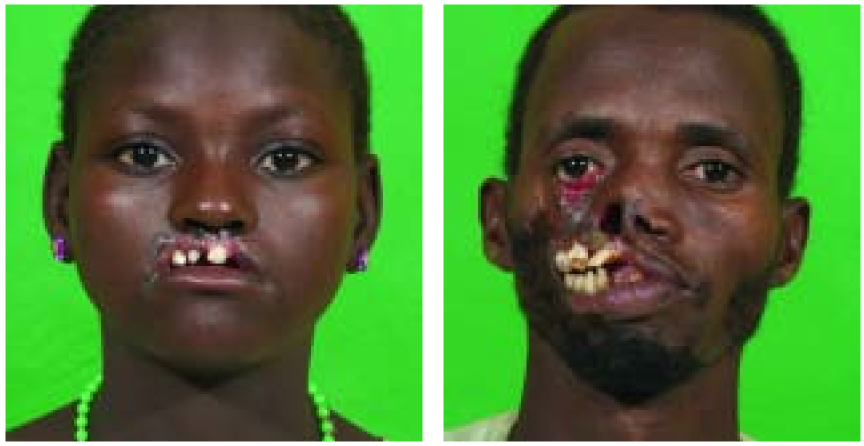

FIGURE 3.20 *Two examples of patients with an upper-lip defect classified as* **U-3**.

FIGURE 3.21 *Two examples of patients with an upper-lip defect classified as* **U-4** *(see also page 104, Fig. 9.3)*.

VI Lower lip (L)

Pattern of defects of the lower lip

- A defect of the lower lip is not very common in noma.
- When it does occur, it leads to problems associated with the leakage of saliva. This is why the disease was called 'water canker' in Europe in medieval times.

FIGURE 3.22 *Boundaries of the lower lip.*

FIGURE 3.23 *Two examples of patients with a lower-lip defect classified as* **L**-1.

FIGURE 3.24 *Two examples of patients with a lower-lip defect classified as* **L**-2.

FIGURE 3.25 *Two examples of patients with a lower-lip defect classified as* **L**-3 *(see also page 69, Fig. 7.26).*


FIGURE 3.26 *Two examples of patients with a lower-lip defect classified as* **L**-4 *(the right picture shows the acute stage of noma;* *see also page 11, Fig. 1.1**).*

VII Particularities (P)

Specific problems

- Loss of lower eyelid tissue. Eyelid retraction by a scarred cheek is not to be noted.
- Affection of the orbit; loss of an eye is seen quite commonly.
- Palatal defects.
- Maxillary sinus defects.
- Loss of premaxilla.
- Loss of skin of the chin.
- Defects of both cheeks.

P-0 means that there are no particularities. If a particularity is found, a brief description should be given as part of the classification.

FIGURE 3.27 *A patient classified as* **P**: *loss of orbital floor.*

FIGURE 3.28 *A patient classified as* **P**: *loss of premaxilla.*

FIGURE 3.29 *A patient classified as* **P**: *loss of the skin of the chin.*

FIGURE 3.30 *A patient classified as* **P**: *loss of orbital floor and eye.*

The NOITULP classification in practice

Thorough examination of a noma patient on the basis of the **NOITULP** classification takes time. It may sometimes be useful to mark key points on the normal side of the face to indicate the normal anatomy as a reference against which the affected side can be compared.

To become accustomed to this classification, readers should study the following pictures and follow the instructions given in the legends.

FIGURE 3.31 *Clinical picture of a noma patient. The reader is asked to classify this patient, with the knowledge that there is a loss of the inner lining of the cheek of > 75%. The actual classification is given in the text.*

FIGURE 3.32 *Clinical picture of a noma patient. The reader is asked to classify this patient, with the knowledge that there is a loss of the inner lining of the cheek of > 75%. The actual classification is given in the text.*

FIGURE 3.33 *Clinical picture of a noma patient. The reader is asked to classify this patient, with the knowledge that there is no loss of the inner lining of the cheek. Be aware that the assessment of the loss of lip tissue does not include only the vermilion but also the skin of the lip and the underlying orbicularis oris muscle. The actual classification is given in the text.*

The patient shown in Fig. 3.31 has been classified as **N**-1, **O**-4, **I**-4, **T**-3, **U**-3, **L**-2, **P**: loss of skin of lower eyelid. The patient shown in Fig. 3.32 has been classified as **N**-0, **O**-4, **I**-4, **T**-3, **U**-2, **L**-1, **P**-0. The patient shown in Fig. 3.33 has been classified as **N**-4, **O**-0, **I**-0, **T**-0, **U**-3, **L**-0, **P**-0. The condition of the vermilion border suggests a classification as **U**-2. However, the substantial loss of orbicularis oris muscle and skin of the upper lip in this patient leads to a final classification as **U**-3.

Regular use of this system may result in a certain jargon. For example a surgeon might tell the anaesthetist to take special care of a particular patient because 'she is a **T**-2', i.e. she has severe trismus with a consequent risk of a difficult intubation.

The experience gained in Sokoto shows that use of the NOITULP classification facilitates the formulation of an effective treatment plan. It takes some time and some imagination to become accustomed to this procedure. With practice, however, a surgeon can be sure that when he has followed the guidelines given above he has examined his patient both thoroughly and systematically.

Philosophy of treatment and timing of reconstructive surgery

4

General considerations

A clear distinction must be made between the acute stage of noma and the late stage in which the patient has survived gangrene, sloughing, sequestration, the formation of granulation tissue, wound contracture and re-epithelialization (Tempest, 1966; Adekeye and Ord, 1983; Marck and De Bruijn, 1999).

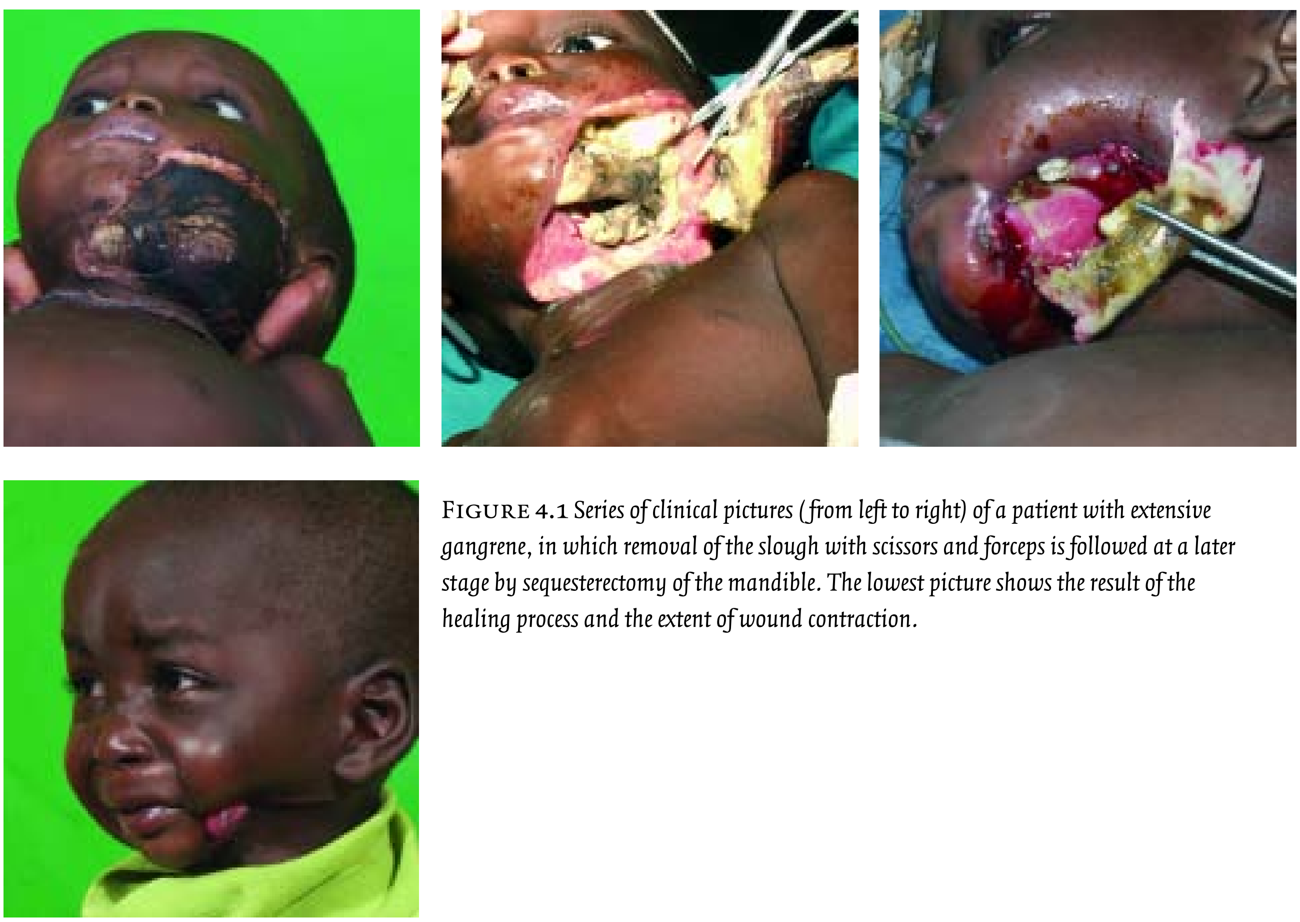

FIGURE 4.1 *Series of clinical pictures (from left to right) of a patient with extensive gangrene, in which removal of the slough with scissors and forceps is followed at a later stage by sequesterectomy of the mandible. The lowest picture shows the result of the healing process and the extent of wound contraction.*

The treatment given in the acute stage should aim at keeping the child alive by administration of antibiotics, hyperalimentation and specific treatment for coexisting diseases. The only indication for surgery at this stage is for urgent control of a secondary haemorrhage. In addition, sequesterectomy may occasionally be useful after sloughing (sometimes assisted by the surgeon's scissors) (Fig. 4.1).

During the anabolic phase of granulation and re-epithelialization, skin grafting on the granulating wounds may speed up the healing process slightly. That is all a surgeon can do at the early stages of the affection.

Once the patient has survived the initial stages and a good nutritional status has been achieved, reconstructive surgical treatment may be considered.

Specific considerations

The surgical rehabilitation of noma patients is one of the most difficult specialties in the field of facial reconstructive surgery. Before embarking on these procedures, the surgeon should take a step backwards and submit his treatment plan to in-depth appraisal with special reference to the topics discussed below.

The sequelae of noma

If the patient survives the acute stage of noma and the prolonged healing of the gangrenous wounds, he inevitably ends up with loss of tissue in the oral region and its surroundings. The final sequelae depend on the site and extent of the tissue loss and the course of the healing process. The healing process is generally marked by re-epithelialization, spread of mucosa, scar tissue formation and wound contraction. The severity of these features can vary appreciably from one patient to another. Some patients show extensive scarring and heavily contracted wounds, while others have supple scars without much contracture.

The most common sequelae of noma are:

- Facial mutilation.
- Incontinentia oris.
- Trismus.
- Feeding and speech problems.
- Deformed dentition.

In general, the surgeon will probably want to correct as many of these sequelae as he thinks he can, to the fullest possible extent. As shown below, however, this well-intentioned aim may not in fact be in the patient's best interests.

Differing perceptions of the benefits and risks of surgery

A noma patient's needs and wishes are largely determined by his or her social and cultural background. It is important for the surgeon to get a clear idea of these requirements and not to be solely guided by his own experience, which we assume to have been gained in a Western context. Before planning the operation in detail, the surgeon must therefore take steps to determine the answers to a number of questions. What is the patient's real problem? What does he expect of a surgical procedure? Does he understand the possible complications and other risks involved?

For example, the surgeon may be so focused on removing the disfigurement caused by a 'hole' in the patient's face that he forgets the implications of a concomitant severe trismus. Before the operation, the patient was able to feed himself through the unsightly hole. If the hole is closed but the trismus is not corrected, the patient has to struggle for his daily intake of calories through the microstomy left after the operation.

Conversely, the patient may have no visible facial disfigurement but may suffer from moderate trismus. Is it really worthwhile putting such a patient through several extensive operations when the final result is a slightly improved ability to open the mouth, no significant improvement in speech and several scars in the face and other areas? It should be borne in mind that even before the operation(s), the patient could manage the limitations caused by the trismus reasonably well because in his culture so much food is traditionally ingested in liquid form. There may thus be little point in subjecting the patient to a long period in the hospital with several episodes of discomfort and pain when the only outcome is considerable facial scarring but little or no functional improvement – certainly from the patient's point of view.

At the same time, it should be noted that the significance of additional (facial) scars produced by the operation may be perceived quite differently by surgeon and patient. In Western cultures, one tries to avoid facial scarring as much as possible, while in some African cultures a scar may actually be seen as a mark of honour (and as a visible sign that the patient was able to afford facial surgery).

When is the right time for the operation?

Considerable thought should be given to the timing of surgery. Patients who have recently survived the acute stage of noma are bad candidates for reconstructive surgery. Their nutritional status needs to be normalized before surgery is considered (Fig. 4.2). In fact, a long period of nutritional support may be needed to bring their general condition up to the level required for extensive surgery.

Further research is needed to provide a basis for effective answers to some other questions. For example, what is the optimal age for reconstructive surgery? Will facial development be adequate after such surgery on a young child? There are reasons to believe that this may not be the case. On the other hand, early release of severe contractures may actually lead to improved growth. Furthermore, extensive operations in young children are associated with a high risk of complications (due to significant loss of blood or lack of postoperative cooperation). Restricted operating facilities may also be a reason to postpone an operation until the age of ten years.

FIGURE 4.2 *A malnourished child is not a good candidate for reconstructive surgery.*

Are the operative and perioperative conditions adequate?

The outcome of a surgical procedure depends not only on the expertise of the surgeon but also on the circumstances under which surgery takes place.

The quality of anaesthesiological support is an important factor in this context. Endotracheal intubation using direct laryngoscopy is impossible if the patient has severe trismus. The anaesthetist should have the skills and equipment needed to deal effectively with this situation. Fibre-optic intubation is generally the solution of choice here, as other methods such as blind intubation, high-pressure ventilation and tracheostomy all have serious drawbacks.

Moreover, hospital staff in developing countries will in general lack the skills needed for prolonged surgical procedures. Experience tells us that when surgery lasts more than four hours, a significantly higher incidence of peroperative and postoperative complications related to anaesthesiological problems may be expected.

The likelihood that blood transfusions will be needed should also be taken into account. Does the hospital have safe (emergency) blood transfusion facilities? If not, such mishaps as accidental severing of the maxillary artery can have tragic outcomes.

Good postoperative facilities are also essential. It is not uncommon for patients who underwent facial surgery without problems to end up in a life-threatening situation due to unnoticed hypoxaemia caused by postoperative intraoral blood loss or swelling. This can even occur after quite simple, short procedures. It goes without saying that a recovery room, with competent staff and adequate equipment, is a prerequisite for noma surgery.

The postoperative care on the ward must also be well organized. Staff must receive proper instruction about possible postoperative problems and the measures to be taken if complications arise. It should be possible to reopen the operating theatre at night without undue problems to deal with a life-threatening complication.

It should be realized that the postoperative care of trismus patients requires dedicated support from committed nurses or physiotherapists over a period of at least six weeks. If this is not available, there is no point in considering the correction of trismus.

Which operative procedure(s) should be used?

For the reasons discussed below, the surgical techniques advocated in this book are relatively simple. Little attention is paid to more advanced techniques – in particular free flap surgery – in despite of their many merits. Free flap surgery based on the use of microvascular anastomosing techniques has been one of the most important advances in reconstructive surgery of the past three decades. It has become well accepted and is now frequently used in many parts of the world to reconstruct large tissue defects in head and neck oncology, in traumatology of the extremities and in breast reconstruction surgery.

Since noma often results in extensive tissue defects, it might be thought that free flap surgery could be an appropriate method of treating the sequelae of noma. While this is perfectly true from a purely surgical point of view, this approach does have some practical drawbacks that need to be mentioned.

Safe free flap surgery implies the availability of a well equipped theatre (with microsutures, long-term anaesthesia, blood-transfusion capacity on demand, and surgeons and staff who are well trained in microsurgical techniques), a good postoperative monitoring infrastructure (in terms of both material and personnel) and facilities permitting immediate reoperation in case of complications. Such advanced facilities are almost always lacking in the parts of the world where noma is prevalent.

In response to this problem, patients are sometimes taken to hospitals in countries where suitable conditions for free flap surgery are available. This approach has however numerous disadvantages:

- It is very expensive.
- It brings the patients into cultural isolation.
- It does not contribute to knowledge transfer and capacity building in the patient's own country.

This book is meant as a guideline for surgeons who are treating noma patients in rural hospitals. The authors have therefore concentrated their attention on relatively simple reconstructive procedures making use of local and pedicled flaps. Free flap surgery and other advanced procedures are mentioned where necessary but are not dealt with in detail.

Under circumstances where free flap surgery is a realistic option (Giessler and Schmidt, 2003; Giessler et al., 2004), it is important to remember that as mentioned above the infrastructure of the hospital should meet certain standards. Moreover, surgeons who plan free flap surgery in these hospitals must have an excellent record in this field to avoid the suspicion that they are experimenting on their patients. Indications for free flap surgery are given in Chapters 8 and 9.

In order to define the operation plan for a given patient, the surgeon needs to take certain mental steps. The first is to imagine the dimensions of the defect after release of contractures and excision of scar tissue. This is not easy, even for an experienced noma surgeon. There is a general tendency to massive underestimation of the extent of the initial necrosis (Fig. 4.3). This finding led to the formulation of 'the Sokoto law of noma surgery':

The flap you need is always larger than you thought – even taking the Sokoto law of noma surgery into account.

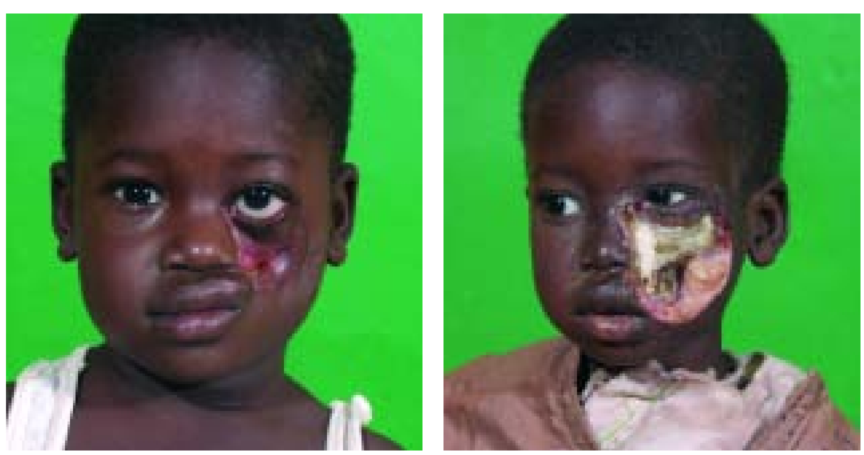

FIGURE 4.3 *A patient with an apparently small defect (left). The initial necrosis included the whole cheek (right).*

Use of the NOITULP classification is a useful aid to visualization of the original defect, since it compels the surgeon to examine the patient in a precise, structured way.

Another useful safety measure is always to plan the length of a pedicle somewhat longer than thought necessary. This gives some leeway if the pedicle turns out to be shorter than intended, and also allows the surgeon to compensate for unforeseen marginal necrosis by advancing a healthier part of the flap as a salvage procedure.

The flaps chosen for reconstruction should ideally offer the following features:

- Thin pliable skin.
- Perfect colour match.
- Easy to apply.
- Reliable.
- Low donor morbidity.
- Low blood loss.
- Preferable one-stage procedure.

Since no flaps meet all these requirements in reality, choices must be made by weighing up the pros and cons of the available flaps. The Tables 4.1 and 4.2, based on data for flaps commonly used in the Noma Children Hospital in Sokoto, Nigeria, may be helpful in this respect.

TABLE 4.1 **Degree of difficulty of flaps and operative techniques commonly used in noma surgery**

Type of flap	Degree of difficulty
Abbe	*
Estlander	*
fan (Gillies, Karapandzic, McGregor)	*
cheek rotation	*
(lateral) forehead	*
(medial) forehead	*
temporoparietal fascia (TPF)	**
deltopectoral	*
submental island	***
pedicled latissimus dorsi	***
pedicled radial forearm	**
free (microvascular)	***

The various flaps and reconstructive techniques described in this book are classified as * (easy), ** (difficult) and *** (complex). The categories * (easy) and ** (difficult) are meant for surgeons not specialized in reconstructive surgery of the face. Flaps and techniques that have been categorized as *** are complex. They are generally used by experienced facial reconstructive surgeons only.

Table 4.2 **Qualifications of the flaps commonly used in noma surgery**

Type of flap	**Thin pliable skin**	**Colour match**	**Reliability**	**Donor morbidity**	**Blood loss**	**Number of stages required**
Abbe	•••	•••	•••	••	•••	2
Estlander	•••	•••	•••	•••	•••	1
fan flaps	•••	•••	•••	•••	•••	1
cheek rotation	•••	•••	••	•••	••	1
(lateral) forehead	••	•••	••	•	••	1 or 2
(medial) forehead	••	•••	•••	•••	•••	2 or 3
superficial temporal fascia	-	-	••	•••	••	2
deltopectoral	••	••	•••	••	•••	2 or 3
submental island	••	•••	••	••	•••	1
pedicled latissimus dorsi	•	•	••	••	•	2
pedicled radial forearm	•••	••	•••	••	•••	2 or 3

••• favourable
•• moderate
• unfavourable
- not applicable

FIGURE 4.4 *Incision of a deltopectoral flap with the aim of avoiding severe microstomia. A formal commissuroplasty is still necessary at a later stage (left). This procedure puts the vascularity of the superior rim of the flap at risk (*), and led to necrosis in this patient (right).*

As outlined in greater detail in the subsequent chapters, it is sometimes mandatory to use combined treatments in order to achieve good results. It should be realized, however, that piling one flap on top of another is not the right approach. The more complicated a case, the more reluctant a surgeon should be to try to solve it in a single (staged) procedure.

A difficult case generally demands a phased treatment programme. For example, a patient with a large central defect involving most of the nose and upper lip and the premaxilla should initially be treated by reconstructing the premaxilla and the upper lip. The nose reconstruction can better be performed at a later stage.

One should also be reluctant to try to solve too many problems at the same time. Take the example of a patient requiring reconstruction of the cheek and the corner of the mouth, where an Estlander flap is not feasible. It might seem attractive to avoid microstomia and create a normal mouth opening by incising deeply the flaps (e.g. a prefabricated temporal fascia and a deltopectoral flap) that form the new cheek and lips. Such a sophisticated approach may however jeopardize the circulation, producing major necrosis in what appeared to be a nicely reconstructed corner of the mouth two weeks before (Fig. 4.4).
In such a case it may be wise to incise the flaps only over a small distance to avoid severe microstomia, leaving the creation of a satisfactory mouth opening till later.

In this context, it is good to remember the words of Michael Tempest, the founder of reconstructive noma surgery. He stated that the chosen methods of repair should be:

- *Simple* (to reduce the number of operations).
- *Safe* (to reduce the number of complications).
- *Sound* (replace the missing tissue by tissue of a similar kind).
- *Satisfactory* (the repair should at least be functionally and cosmetically acceptable, even if it is not aesthetically perfect).

A surgeon should bear all the above-mentioned considerations in mind before exposing a noma patient to the risks involved in any reconstructive procedure. If he is not confident that the procedure he has in mind will really benefit the patient, it is best to stick to the old adage: *in dubio abstine*.

FIGURE 4.5 *A well staffed, well equipped recovery room is mandatory if time-consuming and extensive facial reconstructive procedures are to be carried out.*

Is the level of postoperative care compatible with the surgical procedure?
The surgeon's responsibility does not end with the last stitch. The patient needs a proper bandage, not too tight and not too loose. If pedicled flaps like a DP or radial forearm flap are used, the bandage must restrict patient movement that might put the pedicle at risk. After proper bandaging and detubation, the transport of the patient from the operating table to the hospital bed is another critical moment. The surgeon should assist in maintaining the integrity of the drains and bandages, and in keeping the patient in the proper position.

Good postoperative care in a dedicated recovery room is especially necessary after time-consuming procedures, paediatric surgery, facial and, in particular, intraoral reconstructive surgery. The surgeon should tell recovery-room staff all they need to know about the operation, and should give them full instructions about the drains, the wounds and the required position of the patient.

Satisfactory care can never be obtained if the patient is left to recover on a metal trolley in a busy corridor. Good recovery requires a recovery room that is quiet, adequately staffed and if possible equipped with the necessary monitoring devices (Fig. 4.5). If these conditions are not met, the surgeon must rein in his ambition.

Anaesthesia

5

Introduction

A key feature of anaesthesia in noma patients seeking surgical rehabilitation is the occurrence of severe trismus in one third of the patients. In these patients, oral access is insufficient to permit direct laryngoscopy for endotracheal intubation. A number of ways of getting round this problem have been devised in the past. These include such techniques as guided endotracheal intubation, blind nasal intubation, transtracheal high-pressure ventilation and Seldinger tracheostomy or minitracheostomy.

All these techniques have drawbacks that make them suboptimal and dangerous compared with modern fibre-optic nasal intubation (Fig. 5.1) (Tassonyi et al., 1990). Only if this technique is not available should one consider another technique, define its disadvantages and even reconsider the indication to operate.

Once airway control has been established, anaesthesia follows the normal pattern for an intubated patient undergoing extensive oral surgery. Packing of the throat should be considered obligatory in all such cases. Careful pharyngeal suction after the operation and meticulous postoperative monitoring of a free airway are also of vital importance.

These guidelines are also meant for anaesthetists volunteering for a medical mission as part of a surgical rehabilitation programme abroad. They should be aware that the working circumstances in hospitals in poor countries are very basic. Cultural differences can pose unexpected challenges leading to poor patient care. Experience with nasal fibre-optic intubation techniques is mandatory before embarking on such a mission. Find out well before departure what anaesthetic equipment, gas, drugs and disposables are available locally and what you will have to bring in. It should be noted that time-consuming customs formalities can sometimes be bypassed with the aid of appropriate local support.

FIGURE 5.1 *Fibre-optic intubation is mandatory in noma patients with severe trismus.*

Preoperative considerations

- Check all apparatus and supplies that you may need.
- Check local blood replacement procedures (in particular, the availability of donor blood) on the understanding that severe acute blood loss (due e.g. to haemorrhage from a maxillary artery that is difficult to control) may occur.
- Find out about the prevalence of sickle-cell anaemia and infectious diseases like tuberculosis and malaria in the local population, and check all patients preoperatively.
- Perform a full physical examination (nutritional status, anaemia, upper respiratory or pulmonary infections, cardiac valvular defects) on each patient.
- Identify severe trismus (**T**-2 or **T**-3). If this condition is found, fibre-optic nasal intubation is mandatory. In adult patients this can be accomplished under topical anaesthesia. Slight sedation can facilitate the procedure, in particular when a language barrier hinders communication with the patient. Children usually need general anaesthesia for fibre-optic intubation. It is advisable to maintain spontaneous breathing during the procedure, e.g. by using inhalation anaesthesia.
- Consider the consequences of possible electricity failure (which will occur) and be prepared to deal with them.
- Check the surgeon's plans (extent of procedure, sites of donor flaps, expected duration and blood loss).

Peroperative considerations

- When handing over responsibilities to other people, check their working style and competence.
- Monitoring equipment should be battery-powered (oxymeter) or should have battery backup.
- Use techniques that are locally appropriate.
- Be aware of the possibility of hypothermia (even in the tropics) and take steps to prevent it.

Postoperative considerations

- Be aware that in most hospitals the recovery area is basic or absent, and that the standard of care on the wards is low. So only bring the patient out of theatre after proper recovery.
- Give clear, explicit postoperative instructions.
- See all your patients some hours after surgery and check whether your instructions are being followed.

Management of trismus 6

Introduction

Trismus is defined as the inability to open the mouth normally (hypomobility of the mandible). Half of the noma patients who present for surgery have trismus. In the vast majority of these cases, the trismus is severe (the patient can hardly open the mouth) or complete (the mandible is immobilized, i.e. the patient cannot open the mouth at all). The latter condition is also called ankylosis. While other definitions of trismus and ankylosis may be found in the medical literature, the above will serve our present purposes.

The pathogenesis of trismus, and in particular of ankylosis, can be quite complex. In the interests of a proper understanding of this topic, basic details are given below of the functional anatomy of opening the mouth and ways in which the sequelae of noma can interfere with this process.

Normal mechanisms involved in opening the mouth

Opening the mouth requires activity of the mouth opening muscles (lateral pterygoid, mylohyoid and digastric), and simultaneous relaxation and stretching of the relatively strong muscles that close the mouth (masseter, temporal and medial pterygoid). This is accompanied by movement of the mandible in the temporomandibular joint and stretching of the soft tissues (oral mucosa, facial muscles and skin) that cover the lower jaw and are connected with other parts of the face.

Trismus is not caused by dysfunction of the mouth opening muscles. Their function is hindered by the influence of pathophysiological processes of the skin, mucosa and mouth closing muscles.

Noma-related pathophysiology of trismus

Many pathophysiological processes interfering with normal mouth opening can occur in the months or years between the onset of noma in the oral mucosa and the moment when the patient presents for surgery. Their occurrence and severity depend on the localization and extent of the initial gangrene and the subsequent wound healing (scar tissue formation and wound contraction). See also page 50, Fig. 6.2.

If the gangrene was restricted to the skin, muscles and mucosa close to the mouth, the healing process may result in wound contracture and fibrosis of the adjacent soft tissues. This can prevent these tissues from stretching enough to allow the mouth to open to the normal extent. If the gangrene and surrounding inflammation affect the more lateral parts of the face, other processes may occur. The mouth closing muscles may become fibrotic or necrotic and lose the stretching capacity needed to allow the mouth to open. Even if these muscles are not directly influenced by necrosis and healing processes, they may suffer permanent contracture if they are not regularly stretched (**myostatic contracture**). Pain during the acute stage may induce this process. The temporal muscle seems to be particularly sensitive to myostatic contracture, even on the contralateral side (the side not directly affected by noma). That is why the mouth opening can be increased significantly in many trismus patients by removing the contralateral coronoid process and releasing the temporal muscle.

The constrictive forces resulting from wound contraction, fibrosis and myostatic contracture may be so strong as to result in complete trismus. This condition, known as **fibrotic extraarticular ankylosis**, is not uncommon in noma patients.

If the gangrene also attacks the facial skeleton, the repair processes may cause bony bridges to be formed between the mandible (in particular the coronoid process) and the maxilla, base of skull or zygomatic arch. This ossifying myositis or **bony extraarticular ankylosis** is common in noma patients with complete trismus.

Ankylosis may also result from deformities of the temporomandibular joint itself; this condition is called **intraarticular ankylosis**. The frequency of joint damage in noma patients with ankylosis is unknown. Reliable studies on this topic are lacking. However, the clinical findings in many noma patients with ankylosis who have undergone operation suggest that involvement of the joint is surprisingly low. Extraarticular procedures can lead to a significant improvement in mouth opening in nearly all patients, indicating that the joint has been spared from the destructive forces of the gangrene and can still function even after years of inactivity.

This does not exclude the presence of joint abnormalities induced by the gangrenous process or by growth disturbances, but in practice they do not seem to be clinically common or significant.

Another bony deformity that may influence mandibular mobility is **hypertrophy of the coronoid process** (Fig. 6.1). The coronoid process may form part of a bony bridge between the mandible and other parts of the facial skeleton, as mentioned above, but a hypertrophied coronoid process may also impinge against the zygomatic arch and thus interfere with the mobility of the mandible in that way.

FIGURE 6.1 *Drawing of hypertrophy of the coronoid process causing impingement on the zygomatic arch (left), and an X-ray demonstrating an irregular and hypertrophied coronoid process at the right side of the mandible (right).*

The incidence of coronoid hypertrophy in noma patients with ankylosis is not known. The aetiology of trismus in noma patients is summarized in Table 6.1 and Fig. 6.2.

TABLE 6.1 **Pathophysiology of trismus in noma**

Process	Incidence	Effect
scar formation, wound contracture and fibrosis in facial tissues (mucosa, facial muscles, skin)	always present	partial trismus up to fibrotic ankylosis
fibrosis and/or myostatic contracture of masticatory muscles	common	partial trismus
coronoid process hypertrophy causing impingement on zygoma	unknown	partial trismus up to ankylosis
formation of bony bridges between mandible and facial skeleton	common	extraarticular ankylosis
temporomandibular joint destruction	rare	decreased joint mobility up to intraarticular ankylosis

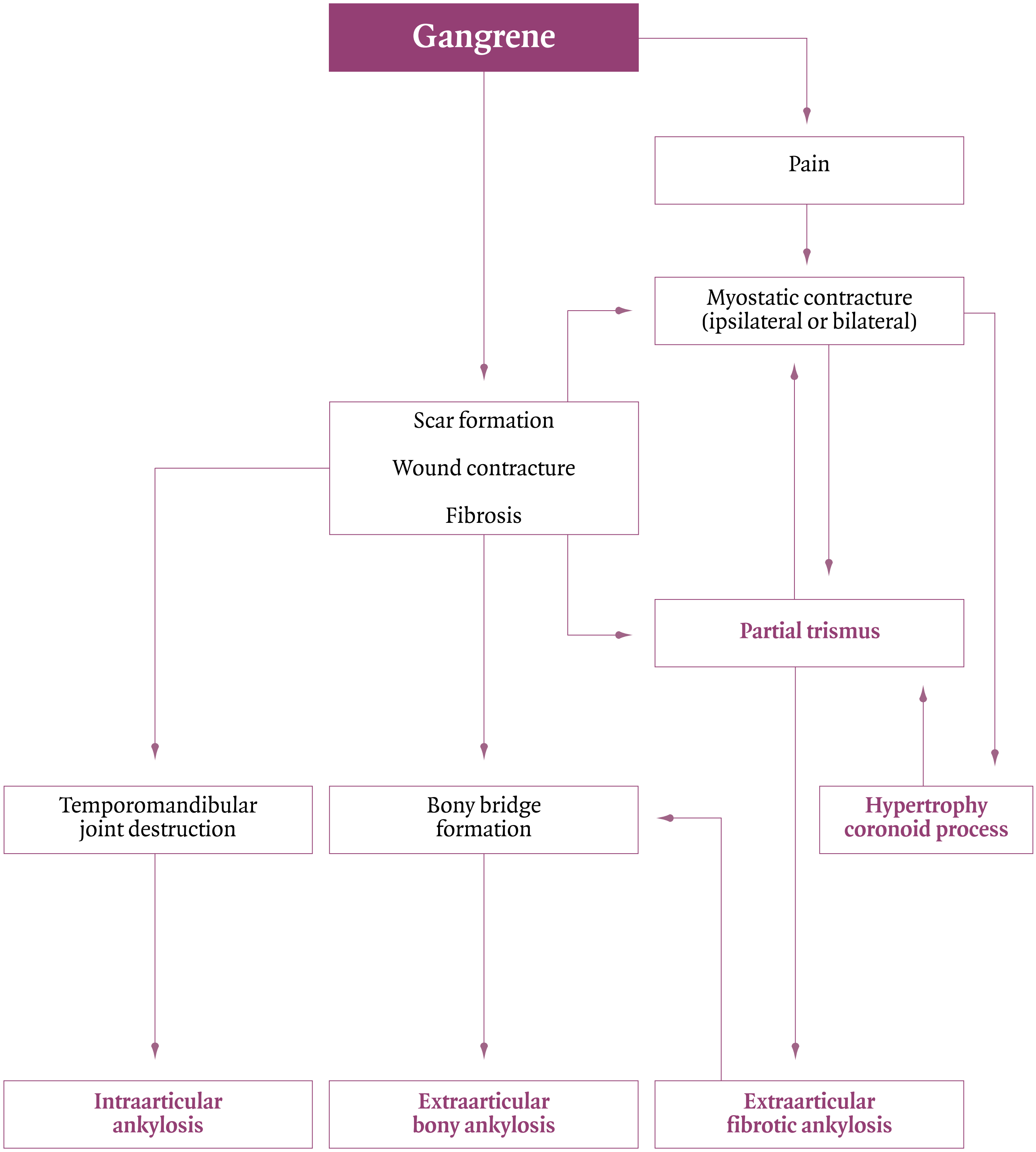

FIGURE 6.2 *Schematic representation of pathogenesis of trismus and ankylosis*

All these factors may play a role in the aetiology of trismus. The problem is that it is very difficult to disclose their respective role preoperatively. Extensive preoperative imaging techniques (such as orthopantomography, CT and MRI) that could be used to elucidate their involvement are generally not available in hospitals where noma patients are to be found. Since thorough clinical examination does not produce much relevant information the surgeon who wishes to improve the mouth opening in a noma patient should follow a rational strategy as outlined below.

Classification

Trismus is included in the NOITULP classification described in Chapter 3 because of its importance as a functional impairment and as a factor to take into account when planning anaesthesia and surgery.

Table 6.2 shows the various possible scores for trismus in the NOITULP classification, with the corresponding measured oral aperture and the common clinical findings. It should be noted that children under the age of 8 years have a normal aperture that is less than 40 mm.

TABLE 6.2 **Trismus classification with corresponding oral apertures and common clinical findings**

Trismus classification	Oral aperture	Common clinical findings
T-0	≥ 40 mm	normal aperture
T-1	20 mm up to 40 mm	fibrotic strings in a mainly supple buccal mucosa
T-2	> 0 mm up to 20 mm	severely fibrotic tissue with much loss of buccal mucosa
T-3	0 mm	ankylosis; hardly any buccal mucosa left

FIGURE 6.3 *The oral aperture can be effectively measured with reference to two fixed points on the anterior parts of the maxilla and the mandible.*

Measurement of the oral aperture

The patient is asked to open the mouth slowly and as far as possible. It is common practice to measure the distance between the incisal edges of the most anterior remaining teeth in the upper and lower jaws (Fig. 6.3). However, this method is inaccurate if these teeth show significant overbite. In this case, or if many teeth are absent or will be removed during treatment, the oral aperture is defined as the distance between two fixed points on the anterior parts of the maxilla and the mandible, measured with the patient's mouth opened as far as possible, minus the corresponding value with the patient's mouth closed as far as possible.

The clinical problem

Partial loss of the capacity to open the mouth need not be a serious clinical problem. If e.g. an adult patient has an oral aperture of 25 mm instead of the normal value of at least 40 mm, this does not really hamper normal oral functions like eating and speech or adequate oral hygiene.
It should further be realized that surgery may actually cause trismus or exacerbate existing trismus, due to new scar formation after an unsuccessful attempt to mobilize the jaw or a failed reconstruction of the inner and outer lining of the cheek. Very careful consideration should therefore be given to any surgical procedure aimed at improving existing oral function. It may be stated that patients classified as **T**-1 do not need special treatment to improve the opening of the mouth, though successful cheek reconstruction can have the side-effect of reducing trismus.

Treatment may be indicated when mandibular movement is so restricted that function is significantly impaired. An aperture of less than 20 mm is likely to be associated with serious incapacity: as a rule, the clinical problems involved will be more severe the smaller the aperture.

Another problem in **T**-2 patients (oral aperture > 0 up to 20 mm) is that oral access is likely to be insufficient to permit direct laryngoscopy for endotracheal intubation.

Surgical treatment of such patients should only be considered if the anaesthetist is able to cope with the sometimes very difficult intubation problems involved. If the technical infrastructure is inadequate (no facilities available for fibre-optic nasal intubation), it is highly inadvisable to try to correct a severe trismus by surgery.

The patient's age and needs should also be taken into consideration. Young patients who are unable to cope with the long and sometimes painful postoperative physiotherapy should not be operated upon. In older patients, extensive preoperative questioning is necessary to determine their real needs, and whether they are sufficiently motivated and able to undergo the operations and long-term postoperative treatment.

Surgical treatment

As mentioned above, slight trismus (**T**-1) is not an indication for surgery. Patients classified as **T**-2 and **T**-3 are considered to have a severe functional impairment. A distinction should be drawn between patients without and with ankylosis. Surgical treatment of a patient without ankylosis is more predictable and generally easier than that of an ankylosed patient.

Severe trismus and ankylosis may give rise to problems such as micrognathia, restricted diet, dental caries, periodontal disease and recurrent abscesses. Wherever possible (in particular, assuming that the trismus allows sufficient access), carious teeth should be extracted, periodontal disease treated and the standard of oral hygiene improved before the operation to correct the trismus. This may prevent subsequent infections.

Indications for surgical treatment are:

- Severe trismus (**T**-2).
- Complete trismus = ankylosis (**T**-3).

Release of severe trismus (T-2) **

Surgical technique

Assuming that initial examination does not provide enough information for detailed planning of the operation, the following rational procedure should be followed.

- Measure oral aperture again after intubation (should be <20 mm; if a larger value is found, reconsider need for operation).
- Release intraoral scar tissue.
- Extract selected dentition and measure oral aperture again.
- If normal, proceed with reconstruction of the inner lining.
- If not normal: osteotomy and removal of **ipsi**lateral coronoid process (preferably by an intraoral approach). If tendon fibres of the temporal muscle remain attached, release them from the ascending ramus. If the masseter muscle is still present, release it.
- Measure oral aperture again.
- If normal, proceed with extraction of selected dentition followed by reconstruction of the inner lining.
- If not normal: osteotomy and removal of **contra**lateral coronoid process (preferably by an intraoral approach). If tendon fibres of the temporal muscle remain attached, release them from the ascending ramus. Release the masseter muscle if necessary.
- Finally, proceed with extraction of selected dentition followed by reconstruction of the inner and outer lining.
- Measure the oral aperture at the end of the operation.

FIGURE 6.4 *A patient with a fibrotic ankylosis (left). Release by scar incision resulted in an oral aperture of 13 mm. Subsequent myotomy of the masseter muscle increased the aperture by 7 mm, while resection of the coronoid process led to a further increase of 10 mm to a final oral aperture of 30 mm (right).* *See also page 28, Fig. 3.15.*

Release of complete trismus = ankylosis (T-3) ***

Surgical technique

Ankylosis due to very tight scar tissue only (fibrotic ankylosis) is not uncommon in noma patients (Fig. 6.4). Even more common is extraarticular ankylosis due to bony bridges between the mandible and another bony structure like the maxilla, zygoma or base of the skull. It is rare that a concomitant intraarticular deformity of the temporomandibular joint contributes to the ankylosis.

The surgical treatment of ankylosis is difficult. It would exceed the scope of this book to describe it in detail, so only a few brief indications are given here. The basic procedure is the same as that given above. The incision of scar tissue and ipsilateral removal of the coronoid process will not be enough to release the trismus, probably owing to the presence of bony bridges. These bridges must now be identified and removed. In many cases, this can best be done using an extraoral approach while excising and releasing the scarred skin and mucosa of the cheek. If significant trismus still persists after the bony bridges have been dealt with, the next step is contralateral coronoidectomy and release of the masseter muscle. If this also fails to resolve the trismus, involvement of the ipsilateral temporomandibular joint may be suspected. Depending on the findings on exploration of this joint, the surgeon may proceed to high condylectomy or a high-gap osteotomy of the ascending ramus. Meticulous smoothing of the osteotomized raw surfaces may help to reduce postoperative pain and scar tissue formation. The sequence of the steps sketched above may be changed on the basis of the perioperative findings.

Problems and solutions

Scar contraction can lead to abnormal anatomy of the maxillary artery and unexpected laceration of this blood vessel. This complication may result in near exsanguinating haemorrhage and can be difficult to control if access to the site of the bleeding is hindered. Methods of control include local pressure with gauze or haemostatic materials and clamping or ligation. The necessary fluid replacement occurs without delay, blood transfusions being given as indicated (and as available) as soon as possible thereafter. Gauze packs may be removed gradually in two or three days or as soon as the patient's general condition has improved sufficiently.

Postoperative treatment

Unfortunately, the improvement brought about by surgical treatment of trismus is often only temporary. This may be due to inadequate bone resection or inadequate reconstruction of the soft tissues, in particular of the inner lining. Radical resection of the coronoid process or the bony bridges is important in this connection. It is not yet known how effective soft-tissue interposition arthroplasty is in preventing recurrence after removal of a bony bridge or gap resection. There are no comparable procedures outside noma surgery, and questions of long-term stability and mechanical endurance remain unanswered. It goes without saying that it is preferable to interpose viable, vascularized flap tissue in the gaps after trismus release. This lowers the risk of infection and may reduce the formation of scar tissue.

The risk of contraction of a flap used for reconstruction is not well known either. Any flap probably runs the risk of secondary contraction when good postoperative mandibular movement is not maintained. There is however no doubt that the chance of secondary contraction is low for skin flaps, higher for flaps lined with a skin graft and highest for unlined flaps.

Adequate postoperative physiotherapy is probably a determining factor in preventing recurrence. It is advisable to keep the mouth open during the first few days after the operation. This can be achieved with the aid of a wooden screw, a bundle of wooden tongue spatulas, an intraoral spacer or, most elegantly, an external fixator between the mandible and the zygomatic body on the contralateral side of the face (Fig. 6.5). While some of these fixators have proved useful in providing guided mandibular movement (by tightening and loosening the distraction gauge – a process known as 'dynamization'), the linear motion is not physiological for the temporomandibular joint though ball joints are mounted on both ends of the fixator. Unfortunately, the pins used to mount the fixator on the patient's face can become loose or infected, or they

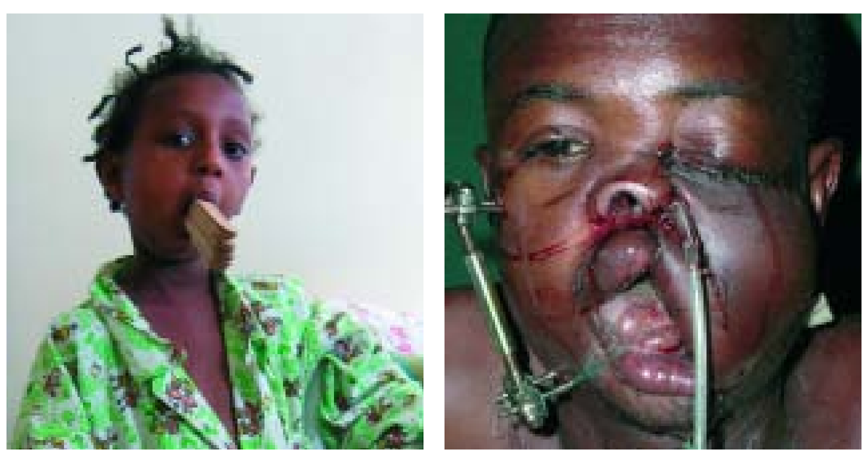

FIGURE 6.5 *The patient's mouth should be kept open after the operation. The use of a bundle of tongue spatulas is simple and effective (left), while application of an external fixator makes postoperative mandibular movement controllable (right).* *See also page 98, Fig. 8.42.*

may simply not be used properly. Further research is needed to determine the limits of utility of these devices.

Physiotherapy should start after the first period of severe postoperative swelling. Application of analgesics may initially be useful. The patient should be trained in moving the lower jaw several times a day. Passive motion may be helpful during the first weeks. These exercises should be supervised daily for at least three months, and the patient should be instructed to continue the exercises for at least another year.

Outcome studies on the treatment of trismus in noma patients are lacking. The treatment plan proposed in this chapter is based on the clinical experience of the few surgeons who have been trained in the treatment of trismus and have gained some experience in dealing with this condition in noma patients. It will be clear to the reader that the management of trismus in noma patients is a difficult surgical field where fools rush in easily, and angels fear to tread.

Reconstruction of the lips and corner of the mouth

7

General introduction

Many noma patients present with a defect involving part or all of one lip. Destruction of both lips is often seen at the angle of the mouth, especially when there is a defect of the adjacent cheek. Separate lesions in both upper and lower lips are rare.

Isolated defects of the upper or lower lip are not accompanied by trismus, though defects of the angle of the mouth often are.

The main goals of treatment of patients of the types indicated above are to reconstruct the mouth so that it opens satisfactorily and to achieve an acceptable cosmetic result. Flaps made of tissues that are similar or identical to those to be replaced will usually give the best results, in line with the motto ‘repair like with like’.

Reconstruction of subtotal or total defects sometimes requires a distant flap, e.g. a radial forearm flap for the upper lip and a deltopectoral or prefabricated temporoparietal flap for the lower lip. After reconstruction of large defects of the lower lip, static support is sometimes needed to avoid sagging and drooling.

Surgical treatment

I Abbe flap *

Introduction

An Abbe flap uses full thickness tissue from one lip to reconstruct a defect of the opposite lip, especially when commissures of the mouth are intact.
For cases of upper-lip defects including the underlying bone, see Chapter 9.

Indications

- Defects of up to half of the lip (**U**-1; **U**-2; **L**-1; **L**-2).
- Large defects of the upper lip (**U**-3) may be reduced in size by releasing the remnants of the lip on each side and advancing them medially towards the midline.

FIGURE 7.1 *Lip defect and design of an Abbe flap.*

FIGURE 7.2 *Creation of an Abbe flap. The pedicle contains the labial artery lying close to the labial mucosa. Compromising teeth are extracted.*

Surgical technique

First stage (mobilization and transfer)

- Mark the outline of the defect to be excised. Note that any part of the lip that is retracted requires complete release (Fig. 7.1).
- Mark the outline of the flap on the opposite lip.
  1. The pedicle of the flap contains the labial artery situated close to the labial mucosa (Fig. 7.2).
  2. Keep the pedicle close to the centre of the defect.
  3. The width of the flap should be at least half that of the defect (up to one-third of the width of the lower lip can be used to provide a flap). Note that the ultimate defect will be smaller after release and advancement of the remnants of the lip. The height of the flap should equal that of the defect.
  4. The design of the flap is usually in the form of a V or, in the lower lip, an inverted M (Figs. 7.2 and 7.6).
  5. If possible, avoid leaving a scar that crosses the nasolabial crease or horizontal mental crease. The height of a flap taken from the lower lip may be increased by lateral extension to each side of the fat pad of the chin (inverted M design).
- Inject adrenaline solution in both lips, avoiding the area around the pedicle. Wait for 5 minutes by the clock to get maximal vasoconstriction.
- It helps to pinch the lip firmly between thumb and index finger to avoid bleeding during incision.
- Create the flap. Incise the nonpedicled side first. **Note the location of the labial artery** between the muscle and mucosa, as this will help later in preparing the pedicle (Fig. 7.2).
- Cut straight through all layers and mobilize the flap. Continue the incision into the vermilion for about 0.5 cm on the pedicled side of the flap. This allows immediate matching of the ver-

FIGURE 7.3 *The flap is rotated through nearly 180° into the defect.*

FIGURE 7.4 *The flap is sutured in three layers from inside out.*

milion-skin junction both at the donor and recipient sites, so that no adjustment is required when the pedicle is divided. Retain a small cuff of subcutaneous tissue, muscle and mucosa around the vascular pedicle. **Do not expose the labial vessels.**

- Rotate the flap through nearly 180° into the defect (Fig. 7.3).
- Close the donor defect and then suture the flap in place, using three-layer closure of the upper and lower lip from inside out (Fig. 7.4).
- Take care when suturing around the pedicle to avoid compromising the blood flow.
- If necessary, release and advance the remnants of the upper lip on both sides of the defect using perialar crescentic excisions, as follows.
  1. Incise from the upper part of the defect around the alar base and continue the incision upwards about $1^1/_2$ cm (Fig. 7.5).
  2. Excise a deep crescent of tissue lateral to this incision.
  3. Mobilize the skin from the maxilla and incise the mucosa along the upper buccal sulcus.
  4. Advance the lip and cheek medially to close the perialar defect and reduce the width of the labial defect (Fig. 7.6).

FIGURE 7.5 *Incision for perialar crescentic excision.*

FIGURE 7.6 *Reduction of a wide upper-lip defect by perialar crescentic excision and advancement of cheek and upper lip. Creation of an inverted M-shaped Abbe flap. Compromising teeth have been extracted.*

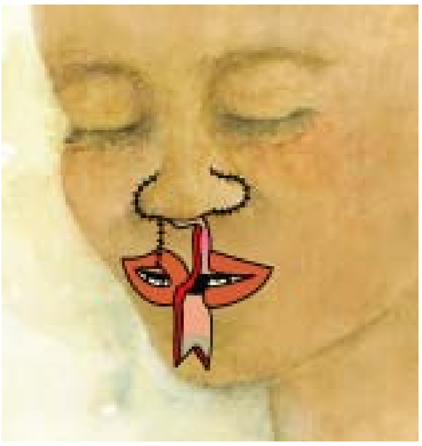

FIGURE 7.7 *Rotation of the Abbe flap after reduction of the width of the defect.*

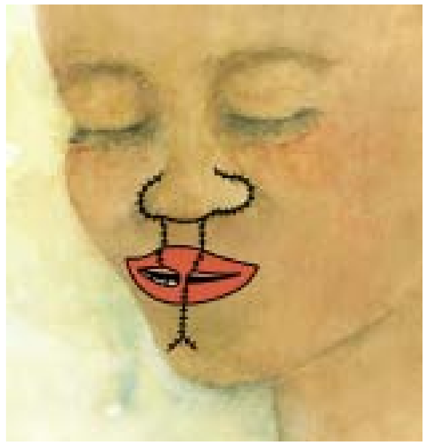

FIGURE 7.8 *The flap is sutured in three layers from inside out.*

5 Rotate the Abbe flap into the defect (Fig. 7.7) and close the upper and lower lip from inside out (Fig. 7.8).

Second stage (division of the pedicle)
- Divide the pedicle after 3 weeks.
- The vermilion-skin junction of the donor and recipient site should be matched precisely.

Problems and solutions
- Injury of the vessels by direct trauma or incorrectly positioned sutures. Persistent cyanosis of the flap calls for suture removal in this area.
- Oral intake of solid food may be difficult. Liquid food using a straw will be necessary.
- Obstruction of the airway may be life threatening. The nose should be inspected and cleaned if necessary on a regular basis.

II Estlander flap *

Introduction
The Estlander flap is used for labial defects that include the commissure. The design of the flap is similar to that of the Abbe flap, but the pedicle becomes the new commissure and the transfer is completed in a single stage.

Indications
- Medium-sized defects of the angle of the mouth (**U**-1, **L**-1; **U**-1, **L**-2; **U**-2, **L**-1). At least two-third of both lips must be preserved, or the oral stoma will become too small.
- The Estlander flap can be combined with another flap in the same stage, for treatment of large defects including the angle of the mouth and the cheek (see also page 88, Fig. 8.24 and page 89, Fig. 8.27).

FIGURE 7.9 *Design of an Estlander flap. The green shaded area should be undermined to release retracted scar tissue.*

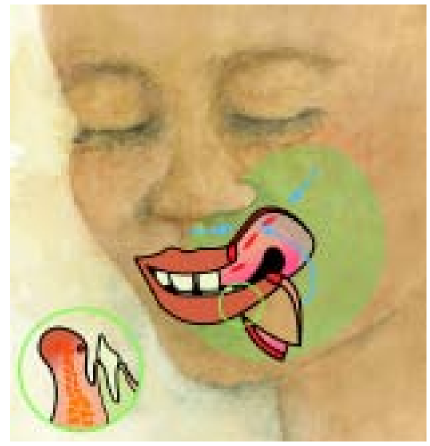

FIGURE 7.10 *The defect of the cheek will be partially closed by advancement of the skin of the cheek. Creation of an Estlander flap. The pedicle of the flap contains the labial artery lying close to the labial mucosa.*

Surgical technique

- The lip with the smaller defect is chosen as donor lip.
- Mark the outline of the area of the defect to be excised. Note that it will be necessary to undermine a wide area and to release any retraction of the lips completely (Fig. 7.9).
- Mark the outline of the flap on the donor lip.
  1. The pedicle of the flap contains the labial artery situated close to the labial mucosa.
  2. The flap should be wide enough to bridge the defect between both lips. Release of a retracted upper and lower lip may reduce the size of this defect considerably.
  3. The design of the flap is usually in the form of a V or an inverted M.
- Inject adrenaline solution in both lips, avoiding the area around the pedicle. Wait for 5 minutes.
- Release the retracted acceptor and donor lips completely. Release and advance the skin from the cheek and close the skin in two layers (Figs. 7.10 and 7.11).
- Raise the flap. Incise the nonpedicled side first. Note the location of the labial artery between the muscle and mucosa, as this will help later when preparing the pedicle.
- Cut through all layers and mobilize the flap. Dissect carefully up to the vermilion on the pedicle side of the flap. Do not expose the labial vessels.
- Rotate the flap through nearly 90° into the defect (Fig. 7.11).
- Close the three layers of the upper and lower lip from inside out (Fig. 7.12).
- If a large defect is present in the cheek, the inner and outer linings will have to be reconstructed with the aid of other flaps during the same stage. Incise the anterior side of the reconstructed inner lining at the level of the angle of the mouth. The triangle of mucosa of the Estlander flap is sutured into this defect in order to minimize future scar contracture at this site. For further details of this procedure see also page 80, Fig. 8.13.

Figure 7.11 *The flap is rotated through nearly 90°.*

Figure 7.12 *The flap is sutured in three layers from inside out.*

Figure 7.13 *Reconstruction of the corner of the mouth by transposition of an Estlander flap and release of the contracted lower lip. The point where the skin of the extra wide Estlander flap is used to increase the height of the lower lip is marked by an asterisk.*

An example of the Estlander procedure is demonstrated in Fig. 7.13 in a patient who previously underwent reconstruction of the cheek with a pedicled latissimus dorsi flap.

Problems and solutions

- Injury of the flap by malpositioned teeth. This should be prevented by extraction of the teeth.
- An Estlander flap procedure leads to a rounded angle of the mouth or even microstomia. Commissuroplasty may be necessary at a later stage (see also page 70, section 7-IV).

III Fan flaps *

General introduction

Most operative techniques for lower-lip reconstruction have been developed to treat lower-lip malignancies. For larger malignancies a rectangular excision is widely used, followed by reconstruction with a fan flap. Three different fan flaps – the Gillies, the Karapandzic and the McGregor – are used for this purpose.

All these reconstructive methods may have a place in the treatment of noma patients. It should be borne in mind, however, that the underlying pathology is quite different in comparison with cancer. The surgeon does not need to aim at safe excision margins and a geometrical starting point as in oncological surgery but should release the scarred tissue and excise it where necessary, and then design a reconstruction that meets the requirements for successful repair. This is more difficult than most standardized oncological procedures and places higher demands on the imagination and creativity of the surgeon.

In general, the lower-lip defects encountered in noma patients represent a loss of all four parts of the lip: the vermilion, mucosa, orbicularis oris muscle and skin. However, unlike the case with oncology patients the loss of the vermilion and adjacent muscle (the lip proper) is relatively less than that of mucosa and generally also of skin. Maybe its good vascularity has provided a certain protection during the occurrence of the gangrene.

Generally speaking, it is wise to oversize the height of the reconstructed lower lip somewhat. One good reason for this is that there is a general tendency to underestimate the height required. Another is that the reconstructed lower lip is bound to sag a little bit. A lip that lacks height never looks good and may give rise to some functional complaints, but one that is (slightly) too high is never a problem.

The description of the use of the three fan flaps given below is meant as a general guideline rather than a strict prescription. An example of a creative modification of the basic design is provided by the case of a noma patient where the lower lip was repaired using a variant of the McGregor fan flap (page 69, Fig. 7.26).

FIGURE 7.14 *Outline of the incision to release the lip and mucosa.*

FIGURE 7.15 *Outline of a Gillies fan flap after release and, where necessary, excision of scar tissue and mucosa. The width of the flap should be a little bit more than the height of the defect.*

IIIA Gillies fan flap *

Introduction

The Gillies fan flap can be used for reconstruction of defects covering 50% of the lower lip. The commissures and superior labial arteries must be intact. It works best for a central defect when a cuff of vermilion is available on each side to suture together. The flap is mobilized and lip tissue is advanced medially towards the other side of the lip defect.

One disadvantage of this method is that the muscle contained in the flap is totally denervated. Another is the displacement of the commissure, resulting in an unnatural appearance or even microstomia.

Bilateral flaps can be used for defects covering up to 75% of the lower lip, provided that vermilion is still present on both sides of the remnants of the lower lip. This approach inevitably results in microstomia.

Indications

- Central defects involving up to 50% of the lower lip (**O**-0, **I**-0, **U**-0, **L**-2).
- Bilateral fan flaps can be used for larger central defects (**O**-0, **I**-0, **U**-0, **L**-3).

Surgical technique

- Mark the outline of the area to be released or excised. Inject adrenaline solution and wait for 5 minutes. Release any retraction of the lip completely (Fig. 7.14).
- Mark the outline of the flap in accordance with the following rules (Fig. 7.15).
  1. Estimate the height of the defect (a’) and determine the required width of the flap (a) on this basis. It is preferable to make (a) a little bit longer than (a’).

2 Draw a line from the deepest point of the defect around the commissure up to the nasolabial fold, parallel to the muscle fibres of the orbicularis oris (b). This outline may be semicircular (centred on the angle of the mouth) or rectangular. A back-cut is made towards the vermilion border (c). This creates a flap with a very small pedicle containing the labial vessels.

- Inject adrenaline solution in both flaps. Avoid the area around the pedicle. Wait for 5 minutes.
- Elevate the scarred mucosa off the mandible (Figs. 7.14 and 7.15).
- Raise the flap. Cut through all layers starting at the deepest point of the defect and proceed around the commissure up to the nasolabial fold and then towards the vermilion.
- Dissect the pedicle carefully up to the vermilion. Do not expose the labial vessels.
- Advance the Gillies fan flap medially (Fig. 7.16).
- Adapt the medial side of the flap to the configuration of the wound of the released acceptor lip (generally a zigzag form).
- Suture the flap in three layers from inside out and close the donor defect by advancement of the cheek (Fig. 7.17).

Problems and solutions

- Injury of the flap by malpositioned teeth. This should be prevented by extraction of the teeth.
- It is important to transfer a redundancy of lip tissue in order to prevent secondary sagging of the lower lip and drooling.
- The full-thickness incision results in denervation. This complete lack of muscle function may lead to problems of oral competence, especially when bilateral fan flaps are used in a large lower-lip reconstruction.
- When this technique is used to correct defects covering over 60% of lip width (**L**-3,4), the resulting microstomia can be troublesome.

FIGURE 7.16 *Advancement of a Gillies fan flap.*

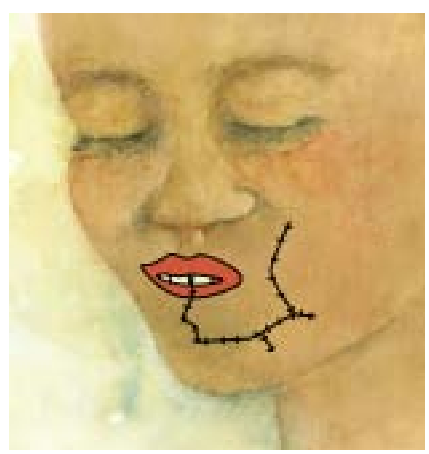

FIGURE 7.17 *The fan flap is sutured in three layers and the cheek defect is closed by advancement.*

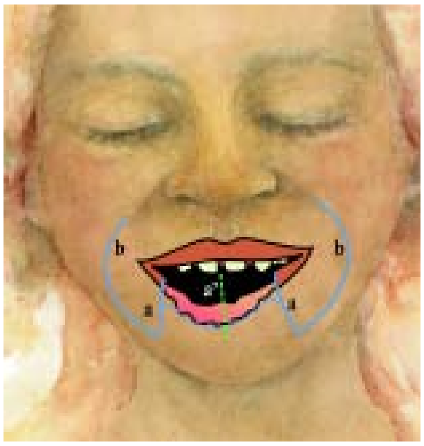

FIGURE 7.18 *Outline of bilateral Karapandzic flaps and of the incision for release of scar tissue and mucosa.*

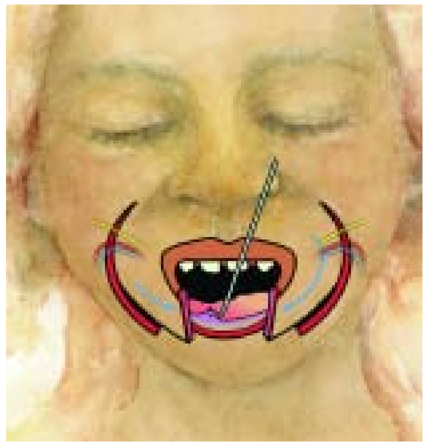

FIGURE 7.19 *The distal halves of the Karapandzic flaps are cut full thickness. More proximally, the muscle fibres are spread out and partially divided with preservation of nerves and blood vessels. A rim of scar tissue has been elevated from the mandible to suture the flaps on.*

IIIB Karapandzic flap *

Introduction

The Karapandzic flap is an arterialized, innervated version of the fan flap. The skin incision is slightly different from that used with the other two fan flaps discussed here, because no back-cut is made. Nerves and vessels are preserved and many muscle fibres are mobilized but not divided. Advancement is reduced because these structures are retained. Bilateral flaps are routinely used to make up for this. The reconstructed lip retains motor power and sensation from the outset, thus enhancing oral competence. Like the Gillies fan flap, this flap is used to repair central lip defects where sufficient lateral remnants of the vermilion are left to advance.

Indications

- Defects of the lower lip covering up to 75% of lip width (**O**-0, **I**-0, **U**-0, **L**-2,3).

Surgical technique

- Mark the outline of the area of the defect to be excised. Note that it will be necessary to release any retraction of the lip completely (Fig. 7.18).
- Mark the outline of the flaps as follows.
  1. Estimate the height of the defect (a') and determine the required width of the flap (a) from this.
  2. Draw on each side from the deepest point of the defect a circular line (b) with a radius equal to the height of the lip defect (a') around the commissure, stopping just short of the alar base. This line parallels the muscle fibres of the orbicularis oris.

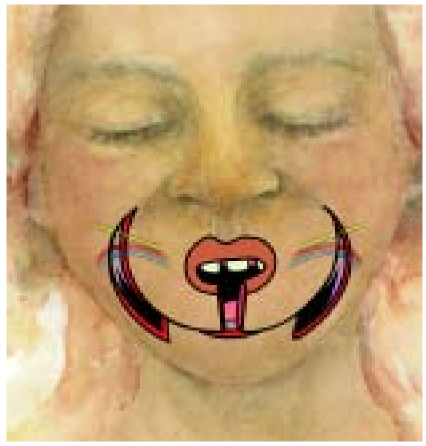

FIGURE 7.20 *Medial advancement of the flaps. Partial release of the mucosa in the proximal half may be necessary.*

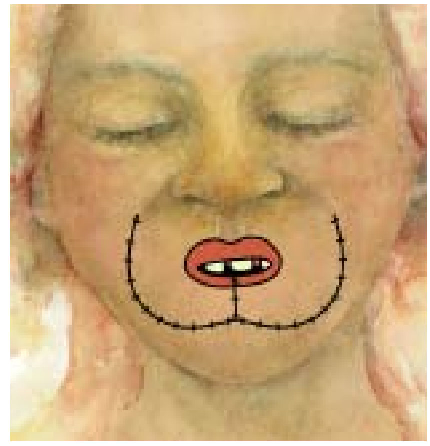

FIGURE 7.21 *Closure in three layers from inside out and from lateral to medial.*

- Inject adrenaline solution in both flaps. Wait for 5 minutes.
- Release the retracted acceptor lip completely. Excise scar contracture of the skin and incise the mucosa at the apex of the buccal sulcus until complete release and advancement are possible.
- Raise the flaps. Full thickness incision of the distal half of the flap. More proximally, the muscle fibres are spread apart longitudinally and partially divided with preservation of the nerves and blood vessels that cross the incision lines (Fig. 7.19). The mucosa of the proximal half of the flap is incised only if it prevents medial advancement of the flap.
- Advance the flaps to the midline (Fig. 7.20).
- Close in three layers from inside out, taking up the disproportion all the way along (Fig. 7.21).

Problems and solutions

- Injury of the flap by malpositioned teeth. This should be prevented by extraction of the teeth.
- Best results are achieved in central defects covering no more than 75% of lip width. Larger defects will lead to microstomia requiring secondary commissuroplasty.

IIIC McGregor fan flap *

Introduction

The design of a McGregor fan flap has certain outward similarities with that of the Gillies fan flap as well as a narrow pedicle based on the superior labial vessels. However, it is in the transfer that differences become apparent. Unlike the Gillies fan flap, where the remaining lower-lip tissue is advanced by rolling the corner of the mouth towards the defect, a McGregor fan flap is transposed 90° with the corner of the mouth as a static pivot point.

FIGURE 7.22 *Outline of the incision to release the lip and mucosa.*

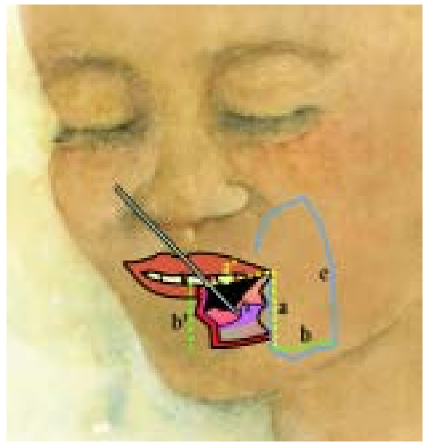

FIGURE 7.23 *Outline of a McGregor fan flap after release and, where necessary, excision of scar tissue and mucosa.*

Bilateral McGregor fan flaps may be used for reconstruction of a complete lower lip. A disadvantage of this type of flap is that it lacks vermilion. Sometimes the remnants of the lower lip vermilion may be sufficient for repair once they have been released and mobilized. If such repair is impossible, the vermilion will have to be reconstructed.

Indications

- Lip defects involving up to 50% of the lower lip (**O**-0, **I**-0, **U**-0, **L**-2).
- Bilateral flaps can be used for larger defects up to complete lip loss (**O**-0, **I**-0, **U**-0, **L**-3,4).

Surgical technique

- Mark the outline of the area of the defect to be released or excised. Release any retraction of the lip completely. Excise the scar contracture of the skin and incise the mucosa at the apex of the buccal sulcus until complete release and advancement are possible (Fig. 7.22).
- Mark the outline of the flap in accordance with the following rules (Fig. 7.23).
  1. Estimate the width of the defect (a') and determine the required length of the distal part of the flap (a) from this. Draw line (a).
  2. The width of the flap (b) should be slightly more than the height of the defect (b'). Draw line (b). This line is to be sutured to the medial side of the defect.
  3. The length of the flap (c) along the cheek is equal to (a + b).
  4. Finish the design with a rectangular back-cut up to the corner of the mouth.
- Inject adrenaline solution. Avoid the area around the pedicle. Wait for 5 minutes.
- Check whether the flap you have designed still fits the defect.
- Raise the flap. Cut through all layers starting at the deepest point of the defect and proceed through the cheek along the lines you have drawn.
- Dissect the pedicle carefully up to the vermilion. Do not expose the labial vessels.
- Transpose the fan flap (Fig. 7.24).

- Adapt the medial side of the flap to the configuration of the wound of the released acceptor lip (generally a zigzag form).
- Suture the flap in three layers from inside out and close the donor defect by advancement of the cheek (Fig. 7.25).
- If necessary, the vermilion can be reconstructed by leaving a rim of mucosa at the medial side of the flap. After transposition, this can be folded over the orbicularis oris muscle and stitched to the skin (Fig. 7.24).

Problems and solutions

- They are similar to those encountered with a Gillies fan flap.

An example of the use of a modified McGregor fan flap in a patient with a large isolated lower-lip defect (**N**-0, **O**-0, **I**-0, **T**-0, **U**-0, **L**-3, **P**-0) is illustrated in Fig. 7.26.

FIGURE 7.24 *Transposition of a McGregor fan flap.*

FIGURE 7.25 *The fan flap is sutured in three layers and the cheek defect is closed by advancement.*

FIGURE 7.26 *A patient with a large isolated lower-lip defect (***N***-0,* **O***-0,* **I***-0,* **T***-0,* **U***-0,* **L***-3,* **P***-0) (left); design of a single fan flap (middle) and result one week postoperatively (right).*

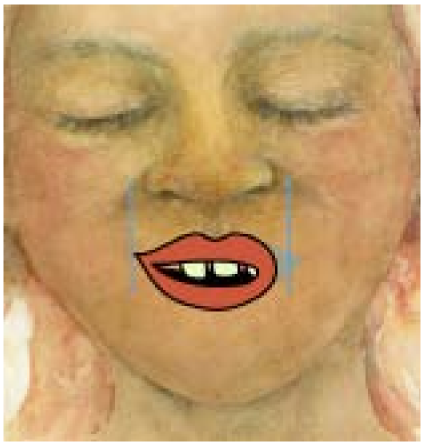

FIGURE 7.27 *Mark the new commissure before intubation and apply some over-correction in the lateral direction.*

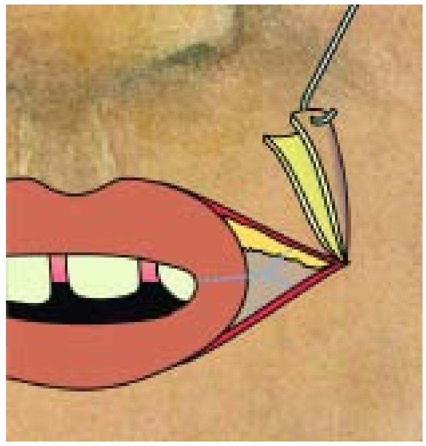

FIGURE 7.28 *Excision of a triangular of skin and the underlying tissue up to the mucosa.*

IV Commissuroplasty *

Introduction

Reconstruction of defects of the lip including the commissure may result in microstomia or a rounded angle of the mouth requiring secondary revision.

Commissuroplasty can be performed 3 to 6 months after the primary reconstruction, when the swelling has subsided.

Indications

- Microstomia. The small mouth aperture may cause functional problems.
- Rounded angle of the mouth. This may give rise to cosmetic problems.

Surgical techniques

- Mark the outline of the skin incision as follows.
  1 Determine the position of the new angle of the mouth by comparison with the opposite commissure, if this is still intact. If oral intubation is to be used during the operation, mark the position of the angle before the tube is inserted. It is useful to apply some over-correction (Fig. 7.27).
  2 Draw a triangular segment lateral to the rounded corner of the mouth, with the apex where the new angle of the mouth is to be.
- Inject adrenaline solution. Wait for 5 minutes.
- Excise the triangular segment of skin and subcutaneous tissue to expose the back of the oral mucosa (Fig. 7.28).
- Make a horizontal incision through the vermilion and oral mucosa to a point 1 cm medial of the new angle. Cut up and down from this point, slightly oblique to the vertical, to create a small oval flap of mucosa in the new corner.

- Transpose the oval flap of mucosa laterally to the new angle, and suture it in place (Fig. 7.29).
- Undermine the inferior and superior mucosal flaps and advance and suture them to form the new vermilion border (Fig. 7.30).
- Alternatively, a curvilinear incision may be made through the lip to create two vermilion flaps (Fig. 7.31). Both flaps are rotated and advanced into position (Figs. 7.32 and 7.33).

Successive steps of the commissuroplasty procedure are shown in Fig. 7.34.

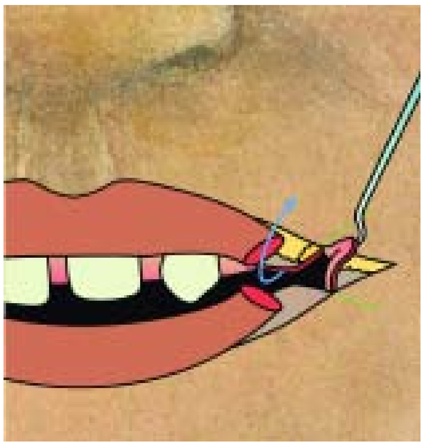

FIGURE 7.29 *A horizontal incision through the vermilion (or skin) and the mucosa. A small triangular flap of mucosa is created.*

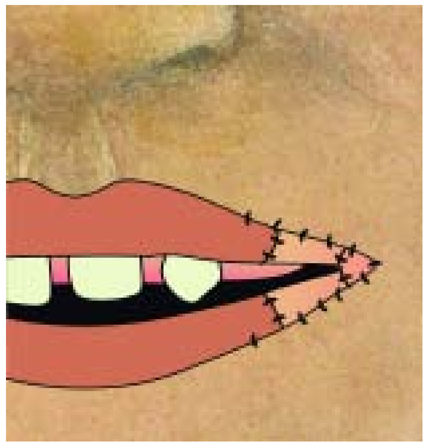

FIGURE 7.30 *The vermilion is reconstructed by advancement of neighbouring mucosa.*

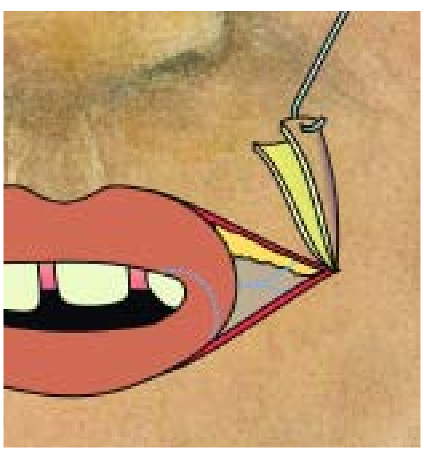

FIGURE 7.31 *Alternative commissuroplasty with a curvilinear incision through the lip creating two vermilion flaps.*

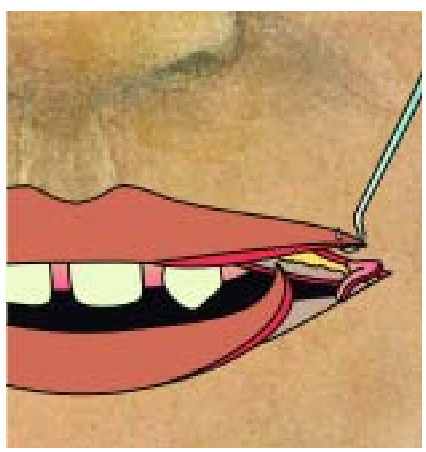

FIGURE 7.32 *Both flaps are rotated nearly to the corner of the mouth.*

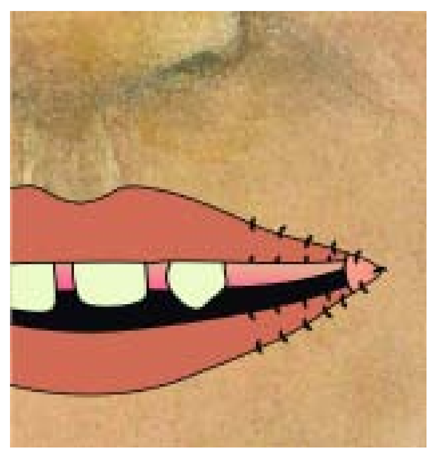

FIGURE 7.33 *A triangular mucosal flap is used to reconstruct the corner of the mouth. The vermilion flaps are sutured to skin and mucosa.*

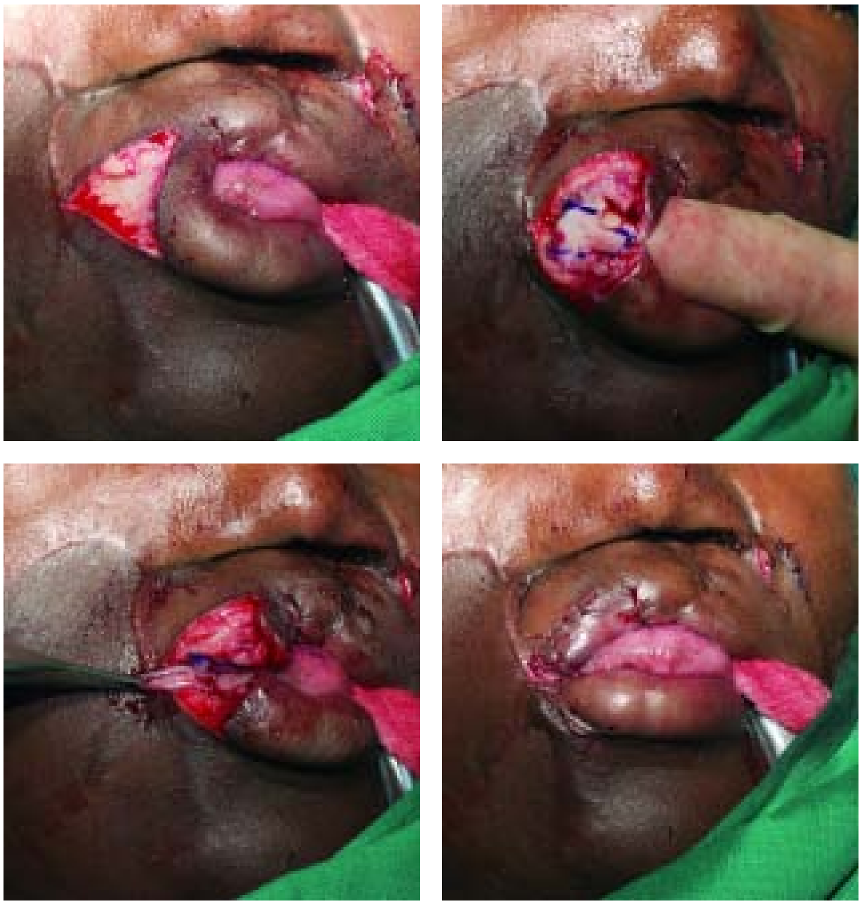

FIGURE 7.34 *Four steps in the commissuroplasty procedure. This patient underwent previously cheek and lip reconstruction with a deltopectoral and an Estlander flap.*

V Regional and distant (pedicled and free) flaps **/***

The pedicled or free radial forearm flap (see Chapters 8-V, 9-III and 9-V) or the prefabricated temporoparietal fascia flap (see Chapters 8-I and 9-II) can be used to treat large defects of the upper lip. The deltopectoral flap (see Chapter 8-IV) or the prefabricated temporoparietal fascia flap (see Chapter 8-I) comes into consideration for reconstruction of the lower lip.

Reconstruction of the cheek 8

General introduction

Defects of the cheek are frequently accompanied by defects of the corner of the mouth, lip or nose. This implies that the operations described in this chapter are often combined with procedures mentioned in Chapter 7 and 9.

It is important to realize that the apparent noma defect is the result of contracted scar tissue. The true defect becomes evident after release and excision of the scar tissue. Take for example gangrene that extended to the cranial half of the cheek and was followed by secondary scar contraction resulting in ectropion of the lower eyelid. When planning a flap for reconstruction of this defect, one should bear in mind that the true defect after release of the ectropion is not only much larger than first imagined but also more cranially located, and might be too large to be dealt with effectively by the flap initially chosen for the purpose.

It is not uncommon for cheek defects to be associated with trismus. Severe trismus (**T**-2,3) will have to be surgically released as described in Chapter 6 before the cheek defects can be dealt with. Restoration of more or less normal mouth opening leads to significant changes in the size, shape and relative proportions of the defects in the outer and inner lining of the cheek. Defects that appeared to be only medium-sized before trismus release can change into large ones afterwards. These alterations are difficult to predict in advance, especially for the inexperienced noma surgeon. Once again, this means that the flap that appeared to be appropriate preoperatively for reconstruction of a certain defect may prove not to be fit for this purpose after release of the scarred and contracted cheek tissue.

There are several good reasons to consider the use of two separate flaps for the reconstruction of the inner and outer lining of the cheek. Firstly, it must be realized that the extent of tissue loss on the inner (mucosal) side of the cheek will most probably be larger than on the outer (skin) side because the gangrene that is the primary cause of the defect typically advances from inside to outside in the shape of a cone (called '*cône gangreneux*' by Reynaud (Reynaud et al., 1961)).

The final defects differ not only in size but also in shape. After release of the trismus, the defect of the inner lining is usually triangular and extends from just anterior of the temporomandibular joint to the midface. Both the size and the shape of the defect in the outer lining may differ quite a lot from this, however. While it can be very large, it can also be limited to a small scar even when associated with severe trismus. The shape is usually irregular, especially around the mouth and the nose.

Secondly, the architectures of the tissues needed for reconstruction of the inner and outer lining differ. An ideal flap for reconstruction of the buccal lining would consist of supple tissue permitting mandibular movement soon after the operation in order to prevent recurrence of the trismus, and would be covered by mucosa with no tendency to contract. Such a flap does not exist.

The prefabricated temporoparietal fascia flap covered with a skin graft does however meet many of these requirements. It is very thin and supple, and reaches the midface. Although initially large enough, it may become appreciably smaller in the long term due to secondary contraction of the skin graft.

An alternative is a skin flap such as the lateral forehead skin flap, since this is less liable to secondary contraction. It is large enough, and reaches the midface. The skin is however quite stiff, and the appearance of the donor site may leave much to be desired after the healing process is completed.

Bilobed or folded pedicled flaps like the latissimus dorsi flap or folded free flaps may provide enough skin for reconstruction of both the outer and the inner lining. They can be very bulky, however, and their application requires considerable surgical experience.

Flaps used for facial reconstruction should resemble the skin of the face as much as possible in colour, texture, thickness and pliability. A flap from the face itself, the cheek rotation flap, may be a good choice for the reconstruction of very small defects. Larger defects generally require reconstruction with locoregional or distant flaps. Locoregional flaps like the deltopectoral, supraclavicular, latissimus dorsi and submental island flap, and distant flaps like the radial forearm flap and free revascularized flaps all have their good and bad points. The deltopectoral flap has established itself over the alternatives because the technique required for its use is straightforward and it has important advantages such as speed, versatility, reliability and low incidence of complications. Although its colour does not match that of the face closely, it is thin and pliable.

Finally, it should be noted that the chance of fistula formation will be smaller when two overlapping, independently vascularized flaps are used than when a single flap is employed with a split-skin graft providing the inner lining.

Reconstruction of the inner lining

I Temporoparietal fascia (TPF) flap **

Introduction

The prefabricated superficial temporoparietal fascia (TPF) flap is close to the ideal for reconstruction of the buccal lining. It is very thin and supple, large enough, well vascularized and can reach about as far as the midline of the face.

It is used in a two-stage procedure, the first stage comprising prefabrication of the flap by applying a split-skin graft to the exposed fascia and the second the transfer of the flap to the face. The pathway below the zygomatic arch is the quickest route for reconstruction of the buccal lining. Like any split-skin graft in the mouth, the TPF flap may have a considerable tendency to contract.

Transfer above the zygomatic arch is useful for reconstruction of central defects like the lining of the nose or the upper lip and premaxilla. This route has the benefit that the vascular pedicle can be mobilized by a further 2 cm.

Indications

- Defects of the buccal lining (**I**-2,3,4) after release of a partial (**T**-2) or complete (**T**-3) trismus.
- Defects of the lining of the maxillary sinus, nose or upper lip and premaxilla (**N**-3, 4, **U**-4, **P**: maxillary sinus, premaxilla).

Surgical anatomy

- The temporoparietal scalp consists of six distinct layers, of which the temporoparietal fascia is the second (Fig. 8.1). It lies under the skin and subcutaneous fat, to which it is firmly bound. Loose areolar tissue separates it from the underlying fascia of the temporalis muscle and the pericranium.
- The thickness of the temporoparietal fascia is about 3 mm.
- The TPF flap is supplied by the superficial temporal artery and vein (Fig. 8.2). The artery crosses the zygomatic arch superficially and is anterior to the auriculotemporal nerve and the superficial temporal vein, where it can be easily palpated. The superficial temporal vessels in this region give rise to the middle temporal artery and vein and cutaneous branches to the upper pole of the ear.

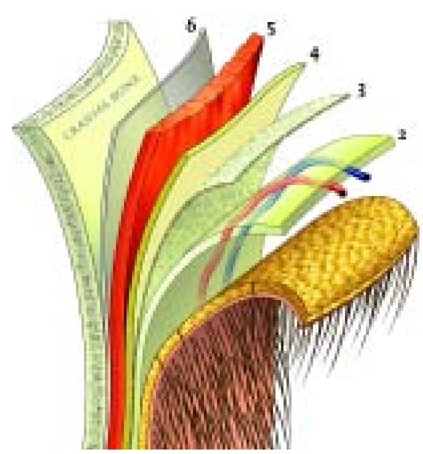

FIGURE 8.1 *Schematic cross-section of the scalp (below the superior temporal line: see also Fig. 8.2) in which six layers may be distinguished: 1) skin and subcutis, 2) temporoparietal fascia, 3) loose areolar tissue, 4) deep (temporalis muscle) fascia, 5) temporalis muscle, 6) pericranium.*

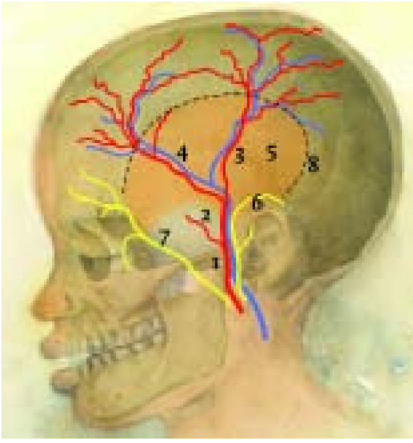

FIGURE 8.2 *The TPF flap is supplied by (the parietal branch of) the superficial temporal artery and vein. The middle temporal artery branches from the superficial temporal artery just superior of the zygomatic arch. The frontal branch of the facial nerve runs obliquely over the zygoma, and the post-auricular nerve posterior to the temporal artery and vein. 1) superficial temporal artery and vein, 2) middle temporal artery, 3) parietal branch, 4) frontal branch, 5) temporalis muscle, 6) auriculotemporal nerve, 7) frontal branch of the facial nerve, 8) superior temporal line.*

FIGURE 8.3 *The course of the superficial temporal artery is outlined on the scalp (above). Doppler ultrasonography is routinely used to locate this vessel (below).*

- The superficial temporal artery and vein divide into a parietal and a frontal branch at approximately the superior limit of the helix. The TPF flap is based on the parietal branch.
- The parietal branch passes vertically upward towards the vertex. Its course can be traced over a distance of about 6 cm by means of Doppler ultrasonography (Fig. 8.3). The TPF flap is dependably vascularized to the midline of the calvarium and may be extended to this point.
- The vein usually runs alongside the artery but superficial to it. At the level of the upper pole of the ear, the vein may take a divergent course and travel up to 3 cm posterior to the artery. It is important to identify the artery and vein before incising the outlines of the flap.
- The frontal branch of the facial nerve runs underneath the temporoparietal fascia, crossing the zygomatic arc obliquely. Care must be taken to preserve the integrity of this nerve during the preparation of the flap. The approximate course of this branch from the main trunk toward the forehead should be drawn to avoid injury to the nerve (Fig. 8.4).

Surgical technique

First stage (prefabrication)

- Fibre-optic nasal bronchoscopy and nasal endotracheal intubation.
- Inspect and clean the oral cavity. Extract all malpositioned and loose teeth and molars. Final assessment of the degree of severity of the trismus.
- Shave the scalp liberally.
- Trace the course of the parietal branch of the superficial temporal artery by palpation in front of the ear, or with the aid of Doppler ultrasonography.
- Mark the outline of the T-shaped skin incision (Fig. 8.5).
  1. Draw a line from a point about 1 cm anterior of the root of the helix and following the course of the superficial temporal artery to the midline.
  2. Draw a line along the midline at right angles to the first and extending about 6 cm in both directions. Cutting along these two lines will expose the temporoparietal fascia in the shape of a triangle with a base 10 - 12 cm long on the midline.
- Inject adrenaline solution in the cranial, anterior and posterior rim of the dissection area and wait for 5 minutes.
- Make the midline incision and incise about 10 cm of the long leg of the T.
- Mobilize the anterior and posterior scalp flaps starting distally and expose the superficial surface of the fascia. The plane of dissection is just below the hair follicles to preserve small veins situated in the thin fat layer overlying the fascia (Fig. 8.6). Tension on the mobilized skin flap with hooks and pressure on the underlying fascia is helpful to visualize the plane of dissection and avoid injury to the hair follicles. Careful haemostasis, preferably bipolar, is mandatory.
- Be aware that the superficial temporal artery and especially the vein lie more superficially in the proximal part of the area (Fig. 8.7).

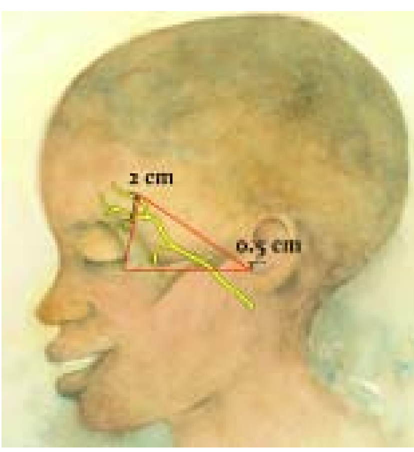

FIGURE 8.4 *Course of the frontal branch of the facial nerve above the zygoma. The danger zone is best localized by drawing a line from a point 0.5 cm below the tragus to a point 2 cm above the lateral eyebrow, and a second line along the zygoma to the lateral orbital rim. The nerve lies underneath the TPF between these two lines.*

FIGURE 8.5 *A T-shaped incision is used in exposing the TPF flap (left). The anterior and posterior scalp flaps are elevated (right).*

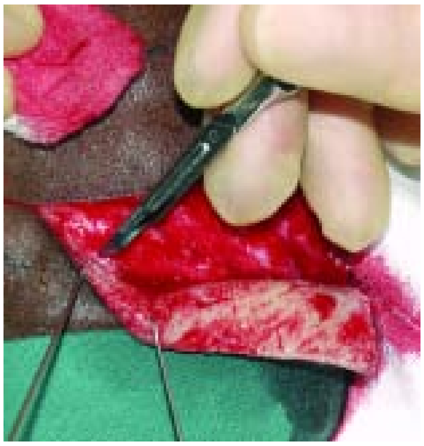

FIGURE 8.6 *The plane of dissection is immediately under the hair follicles. Your scalpel should brush against the underside of the follicles.*

FIGURE 8.7 *Special care must be taken to avoid damage to the temporal vein (marked by an asterisk), which runs in a superficial position directly under the hair follicles.*

FIGURE 8.8 *After dissection of the skin flaps and careful (bipolar) haemostasis, a split-thickness skin graft is applied.*

- Apply a split-skin graft in the shape of a triangle to the cranial, anterior and posterior borders of the exposed fascia (Fig. 8.8). Suture the split-skin graft in place. Avoid injury to the superficial temporal artery and vein at the proximal corner of the triangle.
- Fix a drain and suture the skin flaps. Bandage the head with a slight degree of pressure.

Second stage (mobilization and transfer)

- An interval of approximately 1 week is enough for the graft to take.
- Fibre-optic nasal bronchoscopy and nasal endoscopic intubation.
- Trismus release (see Chapter 6).
  1. Removal of the coronoid process is essential to gain enough space to permit transfer of the TPF flap into the oral cavity.
  2. Preserve a mucosal strip along the mandible and maxilla for fixation of the flap.
- Inject adrenaline solution around the proximal part of the flap.
- Remove stitches and expose grafted surface of the temporoparietal fascia.
  An irregular aspect of the graft, seroma or epidermolysis is not uncommon (Fig. 8.9).
- Prolong the incision downward in the preauricular crease as far as the zygomatic arch. Be aware that the superficial temporal artery and vein are vulnerable in this area (Fig. 8.10).
- Mobilize the scalp flaps and expose a 3 cm wide strip of fascia in the preauricular area.
- Elevate the TPF flap from the midline to the zygomatic arch. The layer of loose areolar tissue between the TPF flap and the underlying pericranium and fascia temporalis permits an easy nonvascular dissection. Do not disturb the skin graft.
- Ligate the frontal branch of the superficial temporal artery and vein at the anterior limits of the flap.
- Identify the superficial temporal artery and vein and mobilize the flap, including a 3 cm wide fascia strip with both vessels, downwards up to the cranial border of the zygomatic arch. Avoid injury to the vascular pedicle.

FIGURE 8.9 *The prefabricated TPF flap one week after skin grafting and re-elevation of the scalp flaps. The skin graft has an irregular aspect due to seroma and epidermolysis. A DP flap and an Estlander flap have also been dissected.*

FIGURE 8.10 *Schematic outline of the second stage of a prefabricated TPF flap, with the wound extended up to the zygoma. The frontal branches of the superficial temporal artery and vein will be ligated. The base of the flap is 3 cm wide, and the fascia flap is elevated as far as the zygoma. Trismus release was performed by a.o. removal of the coronoid process. Mucosal strips along the mandible and maxilla have been preserved.*

- Be aware of the course of the frontal branch of the facial nerve.
- Be aware of the middle temporal artery which branches off the superficial temporal artery just cranial to the zygomatic arch and perforates the deep temporal fascia.

Transfer to the oral cavity below the zygomatic arch

- Make a tunnel below the zygomatic arch towards the oral cavity. The tunnel should be wide enough to pass a finger.
  There are two possible methods of enlarging the tunnel to the desired size.
  1 Excision of the deep temporal fascia below the zygomatic arch.
  2 Outward movement of a segment of the zygomatic arch by means of two osteotomies.
- Insert a tube with a diameter of approximately 1.5 cm in the tunnel. Wrap the flap up with the skin graft on the inside, insert the distal end into the tube and fix it (Figs. 8.11 and 8.12).
- Pull the tube and the flap gently through the tunnel into the oral cavity. Take care that the pedicle is neither overstretched nor twisted. Check the blood supply of the flap.
- Unfold the flap and match its skin-grafted part with the inner lining defect. The deepest point of the defect, anterior to the temporomandibular joint, should match with the top of the skin graft.
- Suture the flap to the mucosal strips along the mandible and maxilla from inside out, starting at the deepest point.

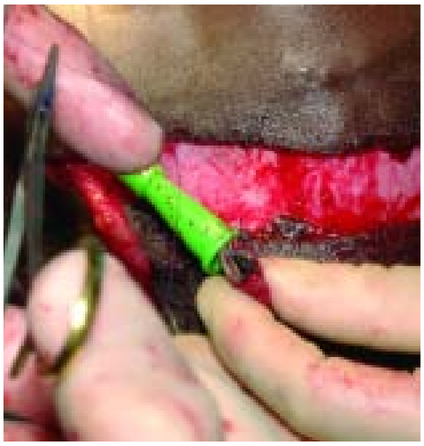

FIGURE 8.11 *A tunnel is made deep to the zygoma towards the oral cavity and a tube is inserted.*

FIGURE 8.12 *The flap is fixed inside the tube and subsequently pulled carefully into the oral cavity.*

FIGURE 8.13 *The TPF flap and Estlander flap have been transposed (left). The fascia flap is incised longitudinally to accomodate the mucosal triangle of the Estlander flap at the corner of the mouth (middle). The tip of the Estlander flap (blue) may be excised for safety reasons. Its complete insertion into the DP flap may jeopardize the blood supply of the cranial part of the DP flap (see also page 42, Fig. 4.4) (right).*

- Suture the anterior part of the flap to the flap used for the outer lining. If an Estlander flap is used for reconstruction of the corner of the mouth, incise the anterior part of the TPF flap to accommodate the mucosal triangle of the Estlander flap (Fig. 8.13).

Transfer to the maxilla or nose over the zygomatic arch

- Make a tunnel below the skin towards the maxilla or nose. The tunnel should be wide enough to pass a finger. Be aware of the course of the frontal branch of the facial nerve.
- If necessary the pedicle can be mobilized downwards over the zygomatic arch for about 1 to 2 cm (Fig. 8.14).

- Insert a tube with a diameter of approximately 1.5 cm in the tunnel. Wrap the flap up with the skin graft on the inside, insert the distal end into the tube and fix it.
- Pull the tube and the flap gently through the tunnel to the maxilla or nose. Take care that the pedicle is neither overstretched nor twisted. Check the blood supply of the flap.
- Unfold the flap and match its skin-grafted part with the defect.
- Suture the flap to the mucosal remnants of the defect from inside out.

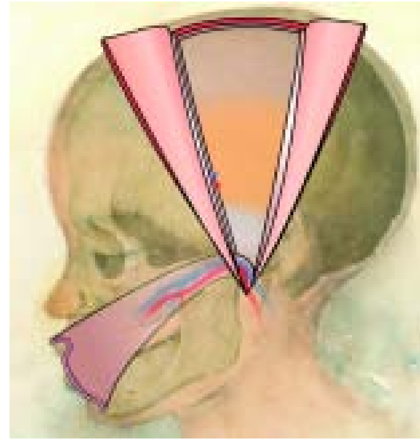

FIGURE 8.14 *The TPF flap is transposed* **over** *the zygomatic arch through a subcutaneous tunnel.*

Problems and solutions

- Damage to the vascular pedicle of the flap. Be aware that the two blood vessels involved may not follow exactly the course indicated above and identify the artery and vein before incising the outlines of the flap.
- Secondary alopecia around the incision site. The scalp flaps should be mobilized by dissecting in a subfollicular plane. Choosing the plane of dissection too superficial can result in damage to the hair follicles.

II Lateral forehead flap *

Introduction

When the forehead flap is used for reconstruction of the inner lining of the cheek it is laterally based and includes the entire hairless forehead (Fig. 8.15). It is easy to use in a two-stage procedure (first stage: elevation and transfer and second stage: division of the pedicle). The flap may also be used in a one-stage procedure by de-epithelializing its pedicle. The route into the mouth should be superficial to the zygomatic arch. Since the flap approaches the defect from above, downward pull is avoided.

The flap using the whole forehead is safe and reaches the anterior part of the mouth without tension. An advantage of any skin flap is that secondary contraction is minimal. This skin flap is less supple than other skin flaps, and much less supple than the TPF flap.

The donor defect is covered with a split-skin graft, which may result in an ugly scar. Brow function is completely lost.

Indications

- Defects of the buccal lining (**I**-2,3,4) after release of partial (**T**-2) or complete (**T**-3) trismus.

Surgical anatomy

- The flap is supplied by the frontal branch of the superficial temporal artery and vein.

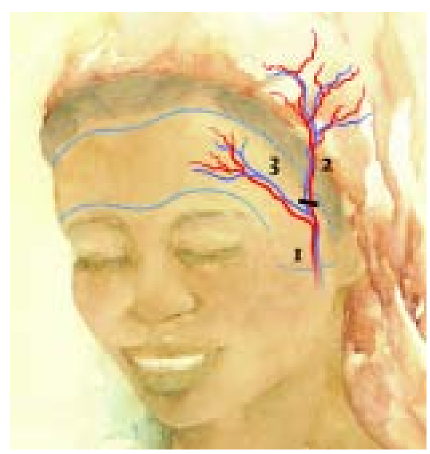

FIGURE 8.15 *Schematic outline of the lateral forehead flap and its blood supply, based on the superficial temporal artery and vein. 1) superficial temporal artery and vein, 2) parietal branch (ligated), 3) frontal branch.*

The superficial temporal artery is palpable anterior to the tragus of the ear and can be traced with the aid of a Doppler probe to the level of its bifurcation into the frontal and parietal branches. When the flap is raised to its full extent the parietal branch of the superficial temporal artery and vein, the supraorbital and supratrochlear vessels, the supraorbital sensory nerves and the frontal branches of the facial nerves are all divided.

- The flap curves across the hairless forehead and its base extends from the lateral border of the eyebrow to the anterior border of the ear just above the zygomatic arch. If the flap extends to the opposite hairline, its dimensions may be as much as 15 x 5 cm, allowing it to extend across the midline after transfer.

Surgical technique

First stage (elevation and transfer)

- Trace the course of the superficial temporal artery in front of the ear by palpation and the course of its frontal branch by means of Doppler ultrasonography.
- Mark the outline of the skin incision. The base of the flap is just above the zygomatic arch.
- Inject adrenaline solution round the perimeter of the flap excluding the base and wait for 5 minutes.
- Elevate the flap at the level of the periosteum and take care to leave a layer of pericranium behind.
- Begin flap elevation at the distal margin and continue until the ipsilateral eyebrow and zygomatic arch are reached. Divide the parietal branch of the temporal superficial artery and vein and proceed deep to the temporoparietal fascia.
- Create a tunnel just below the zygomatic arch. This is done in two distinct steps: first the skin incision down to the parotid gland, of length equal to at least two-thirds of the width of the flap, and the remainder by blunt dissection. Avoid making the tunnel too tight. Obvious complications from the use of such a tunnel are facial palsy and salivary fistula.
- Fold the flap laterally and pass it through the tunnel (Fig. 8.16).
- Tailor the flap to fit the defect and suture it to the mucosal strips along the mandible and maxilla.
- Graft the donor site with a one-piece split-thickness skin graft and cover the raw surface of the pedicle with a skin graft extending to the point where the flap enters the tunnel. Alternatively, the raw surface of the pedicle may be left ungrafted and dressed until the bridge segment is returned.
- Avoid drying and mummification of the pericranium under the heat of the operating theatre lamp.

Second stage (division of the pedicle)

- Vascular attachments between flap and acceptor site are adequate after 5-6 weeks.
- Mobilize the flap in the tunnel from the outside into the mouth, exert traction on the flap and

divide it as far down the tunnel as possible. It is important to leave an empty tunnel and an unobstructed opening from the tunnel into the mouth that drains freely and will not fill with fluid.

- The bridge segment is returned to the temple and the distal end of the flap left in the tunnel is pushed through into the mouth and trimmed if necessary. It is better not to suture intraorally.

FIGURE 8.16 *Schematic outline of the lateral forehead flap. The flap is folded and passed through a tunnel towards the oral cavity.*

One-stage procedure (de-epithelialized pedicle)

- De-epithelialization of the tissue overlying the vascular pedicle permits a one-stage procedure. It should be noted, however, that this modification is technically more difficult to perform (Fig. 8.17).

Problems and solutions

- The major cause of necrosis is failure to make the tunnel wide enough to accommodate the flap.
- Facial palsy. A safe way through the diverging branches of the facial nerve is made by using a scissor with blunt points, the path being created by opening the blades.
- Salivary fistula. Since the line of the tunnel is downwards and medial, the parotid gland is the one that might cause trouble. Any fistula would be glandular and will drain into the mouth.

FIGURE 8.17 *De-epithelialization of the vascular pedicle of the lateral forehead flap allows it to be used for reconstruction of a large inner lining defect as well as a skin defect in a one-stage procedure. Classification:* **N**-0, **O**-2, **I**-4, **T**-2, **U**-1, **L**-1, **P**-0. *Outline of the lateral forehead flap (left). Elevation of the flap, de-epithelialization of its pedicle and dissection of the skin of the cheek to facilitate passage of the forehead flap (middle), and immediate postoperative result after reconstruction of the inner and outer lining with a folded lateral forehead flap (right).*

Reconstruction of the outer (and inner) lining

III Cheek rotation flap *

Introduction

The inferiorly based cheek rotation skin flap may be used for reconstruction of small skin defects without trismus or even with severe trismus. It can be raised relatively easy, has a good blood supply and will give an excellent colour and texture match. It may be extended around the ear lobe and down the neck. This flap is very useful for closure of defects in the infraorbital and nasolabial regions.

This procedure has however many disadvantages: a) it requires the skin defect excised to be given a triangular form, which may not match the actual situation, b) a large flap is needed to achieve satisfactory reconstruction, even if the defect itself is small, and c) this flap is difficult to mobilize and transpose in young children, because the face of a young child has a good deal of puppy fat in the subcutaneous layers.

The possible shift and excess of skin may be assessed by pushing the skin of the cheek in a medial direction with all the fingers of the hand. Reconstruction with a cheek rotation flap should be possible if this excess is at least equal in size to the defect.

Indication

- Small skin defects (O-1) in the infraorbital, paranasal and nasolabial areas. The cheek rotation flap may suitably be used in combination with an Estlander flap.

Surgical technique

- Mark the triangular outline of the defect to be excised. Note that the true shape and extent of the defect only become evident after release and excision of the scar tissue.
- Mark the outline of the flap, as follows (Fig. 8.18).
  1. The anterior margin of the flap is slightly larger than the defect.
  2. The cranial margin of the flap initially rises over the zygomatic arch to prevent downward retraction of the lower eyelid following transfer and suturing of the flap.

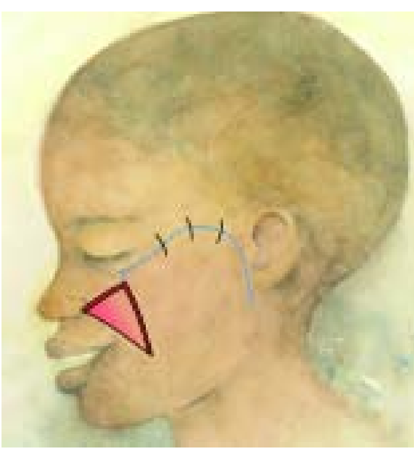

FIGURE 8.18 *Schematic outline of the cheek rotation flap. Using a rotation flap, the defect excised must be given a triangular form.*

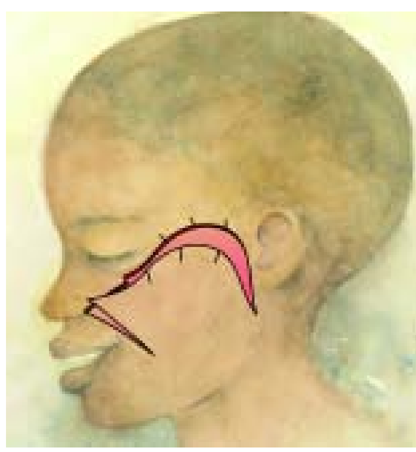

FIGURE 8.19 *Marks have been placed along the border of the flap to demonstrate the extent of medial rotation.*

FIGURE 8.20 *Suturing should start in the temporal region and proceed medially. All tension should be transferred to the temporal region.*

3 The posterior margin runs downwards in the preauricular area and may continue around the lobe and down into the neck.

- Inject adrenaline solution around the planned incision and beneath the flap. Wait for 5 minutes.
- Excise the defect and release the scar contracture.
- Check the outline of the flap against the defect after contracture release and continue with reconstruction of the mouth if no major discrepancies are found. If the flap is too small, it may be necessary to discontinue the procedure.
- Elevate the flap without damaging the underlying branches of the facial nerve. The skin of the whole cheek should usually be elevated (see also page 83, Fig. 8.17 (middle)). The larger the defect, the more extensive the undermining and mobilization required.
- Pull the flap with hooks to ensure that enough advancement has been gained and adequate closure is possible (Fig. 8.19).
- Perform meticulous haemostasis (these flaps have a reputation for haematoma).
- Suture the flap in position. Some temporary positional sutures in the temporal region may be useful initially to check whether the rotation will allow the tip of the flap to be brought to the area of the defect without tension. Take care to ensure that all tension is exerted craniolaterally of the orbit, in order to avoid an ectropion (Fig. 8.20).
- Start closure in the temporal region from lateral to medial, using each stitch to promote rotation of the flap. The suture holding the tip of the flap in place should be tension-free. Check the vascularization of this part of the flap, which is crucial for the success of the procedure.
- Finally, close the preauricular region from cranial to caudal, leaving a dog-ear caudally.
  If the tip of the flap is not well vascularized at the end of the operation, remove the stitches and consider whether the tension can best be reduced by elongation of the incision caudally or by applying a large skin graft to the preauricular area. This graft can be excised or reduced at a later stage.
- Leave a drain.
- Correct the dog-ear by excision at the base of the preauricular region.

Problems and solutions

- Ectropion of the lower eyelid due to poor flap design.
- Ischaemia and loss of the tip of the flap due to inadequate undermining, inadequate planning and too much tension on the flap. A postoperative haematoma may lead to ischaemia and flap necrosis. A prompt evacuation and careful haemostasis should be performed.

IV Deltopectoral (DP) flap *

Introduction

The deltopectoral (DP) flap is regarded as old-fashioned in modern facial reconstructive surgery, but is still a reliable workhorse in noma surgery. The procedure is safe, simple and satisfactory

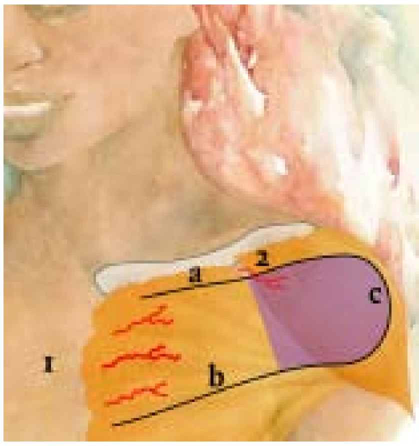

FIGURE 8.21 *Schematic representation of the DP flap showing its arterial vascular supply and its random pattern extension (shown purple). 1) perforating branches of the internal mammary artery, 2) branch of the acromiothoracic artery.*

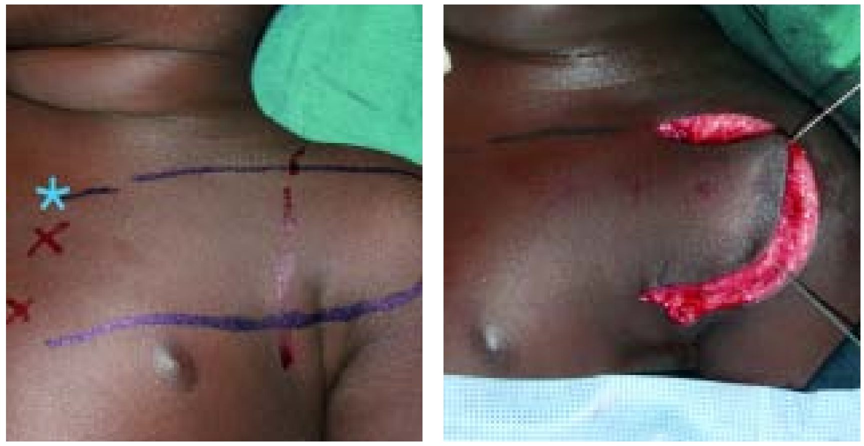

FIGURE 8.22 *Outline of a DP flap. The pivot point of the DP flap is marked by an asterisk (left). Delay procedure for a DP flap: the distal part of the DP flap is elevated from the underlying muscle as far as the deltopectoral groove. The deltoid branch of the acromiothoracic artery should be divided in the infraclavicular fossa (right).*

and provides a large area of supple skin, generally with a reasonably good colour match to the face. The flap never has to be defatted.

The main disadvantages of this procedure – the fact that it consists of three stages, and thus requires a long admission time and a skin-grafted donor area – do not weigh heavily for most noma patients.

Indications

- Skin defects of the cheek (**O**-2,3,4).
- Defects of the chin (**P**: loss of skin of the chin).

Surgical anatomy

- The DP flap is an axial pattern flap deriving its blood supply from the parasternal perforators of the internal mammary artery and vein (Fig. 8.21). The second and third perforators are usually the largest and emerge in the easily palpated rib interspace close to the lateral border of the sternum.
- The vessels of the DP flap run in a plane superficial to the fascia.
- The territory of the perforators of the internal mammary artery and vein extends as far as the groove separating deltoid from pectoralis major. The part of the flap raised beyond this should be regarded as a random pattern flap at the end of the axial element of the DP flap.

The length of this random pattern extension regarded as safe is roughly equal to the width of the flap, making the extension approximately square.

- With this design, the DP flap can be raised without prior delay. However, serious problems of necrosis may arise in malnourished patients or when attempts are made to increase the length of the flap, **which is not recommended**. For reasons of safety, the routine practice is to delay every DP flap in noma patients.
- The purpose of the delay is to restrict the blood supply of the flap to that on which it will have to rely at the time of transfer, without adding the strain of the actual transfer itself. Successful delay of a DP flap involves interruption of the cutaneous branch of the thoracoacromial artery and the myocutaneous branches arising from the deltoid. This is achieved by elevation of the tip of the flap as far medially as the groove between deltoid and pectoralis major and undermining in the infraclavicular fossa.

Surgical technique

First stage (delay procedure)

- The delay procedure of the DP flap is usually combined with prefabrication of the flap that will be used for reconstruction of the inner lining, examination of the degree of trismus, inspection and cleaning of the oral cavity and, if necessary, extraction of teeth.
- Mark the outline of the flap (Fig. 8.21).
  1. Parallel and just inferior to the clavicle (a).
  2. Parallel to the clavicle and just cranial to the anterior axillary fold (b).
  3. Approximately as far as the mid-lateral line of the deltoid (c).

  This design means that the second, third and possibly the fourth perforator is incorporated and gives a flap width of approximately 12 cm in adult patients.

  The length of the flap is determined by measuring the length its needs to reach the defect without tension. For reasons of safety the length of the extension lateral to the groove separating deltoid from pectoralis major should not exceed the flap width.
- To assess whether the flap is long enough, cover the designed flap with an unfolded gauze and use this to simulate the transfer of the flap to the cheek.

  The presence of slack skin in the anterior axillary fold (to allow abduction of the shoulder) means that the lower border of the flap is considerably longer than the upper border (Fig. 8.22). Any tension developing when a DP flap is transferred tends to be along the shorter upper border. For this reason the pivot point of the flap is the medial end of the upper border of the flap. Therefore the reach of the flap is determined from this point.

  Since the patient's head is usually extended when he or she is lying on the operation table, care should be taken not to stretch the flap to its limit. Depending on the patient's stature, the distal part of the flap may not reach the cranial part of the cheek. Optimal is when the patient has broad shoulders and a short neck.
- Inject adrenaline solution around and beneath the distal end of the flap. Wait for 5 minutes.
- Dissect the flap off the underlying deltoid muscle, leaving the fascia on the flap, as far as the

groove between the deltoid and pectoral muscle. The cephalic vein may be kept intact but the deltoid branch of the thoracoacromial artery should be divided by undermining the infraclavicular fossa (Fig. 8.22).

- Resuture the flap in its original position and leave a drain.

Second stage (mobilization and transfer)

- This stage can be performed when the wound of the delay procedure has healed; this usually takes 7 days.
- Mobilization and transfer of the DP flap represent the final part of the second stage, which includes release and excision of scar tissue, trismus release and reconstruction of the inner lining and corner of the mouth.
  A cicatricial ectropion should also be corrected during this stage. The downward contracture of the lower eyelid should be corrected by release of all scar tissue, and skin defects should be treated by a (almost too) high inset of the flap with which the skin of the cheek is reconstructed. If that is not possible, a full-thickness skin graft should be applied. Pedicled flaps as from the upper eye lid are to be used in secondary procedures.
- Redraw the design of the flap. Palpate the 2nd, 3rd and 4th rib interspace close to the lateral border of the sternum and mark the position of the perforators.
- Remove the stitches and excise necrotic tissue at the tip of the flap, if present.
- Elevate the flap from lateral to medial. The medial extent of the dissection is usually to a point approximately 2 cm lateral to the sternal border. **Do not identify the internal mammary perforators.**
- Transfer the flap to the cheek, adapt the shape of the flap to the defect and suture the flap in position. The bridge segment is usually tubed by suturing the rims of the flap together (Figs. 8.23, 8.24 and 8.25). All tension should be avoided, and these stitches should be removed if there is the slightest doubt that they are giving rise to tension.
- Cover the permanent secondary defect on the deltoid with a skin graft. The remainder can be partially closed and skin grafted or, better, treated as a temporary raw area dressed with paraffin and cotton gauzes. This area will be closed when the bridge segment is returned to its preoperative site following division of the pedicle.

FIGURE 8.23 *The arc of rotation of both the DP flap and the TPF flap are demonstrated before definite transfer.*

FIGURE 8.24 *The DP flap, TPF flap and Estlander flap have been transferred and sutured in place.*

- Apply strapping in the form of wide strips of adhesive tape to the patient's head, shoulder and trunk to avoid tension on the pedicle caused by stretching or twitching of the neck.
  An especially close watch should be kept on the patient during the first few hours after the operation, when signs of restlessness are often observed. Unwanted movements of the head at this stage may seriously jeopardize the final outcome.

Third stage (division of the pedicle)

- Vascular attachments are, as a rule, adequate 5-6 weeks after transfer. Whether division is safe depends also on additional evidence such as the extent of surrounding scarring, the course and speed of healing and the presence of local induration. It is generally better to wait another week or even several weeks rather than to risk necrosis.
  When in doubt, observe the perfusion of the flap after temporary clamping of the pedicle with a slack bowel clamp.
- Divide the pedicle, leaving enough tissue attached to the head for the inset of the flap (Figs. 8.26 and 8.27).
- If back flow is excellent, it is safe to proceed with immediate flap inset.
- When in doubt, postpone the final flap inset for a week. This procedure involves some dissection of the flap back from the initial inset and slight thinning so that the flap sits neatly. If the blood supply is not optimal, this can cause rim necrosis.
- Convert the pedicled tube to a flat flap and return it to its preoperative site. Suture it in position. Meticulous suturing should be avoided because the donor area is contaminated after weeks of open wound treatment. Leave a drain.

Problems and solutions

- Partial tip necrosis. Delay of the distal part of the flap will usually preclude this complication as long as the random pattern extension is not too long. Necrosis, if present, should be excised before flap transfer.
- Partial or total avulsion due to tension on the pedicle may call for resuturing of the flap.

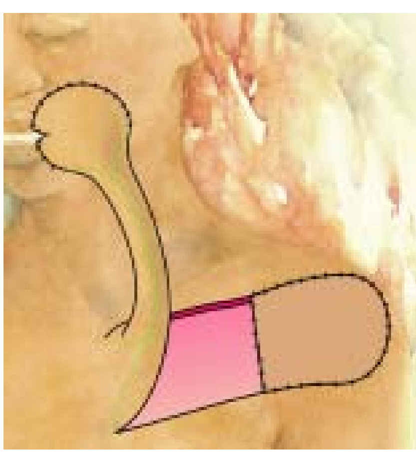

FIGURE 8.25 *Schematic representation of the transfer of a DP flap. The flap is sutured in the face, the pedicle is tubed and the donor defect on the shoulder is grafted.*

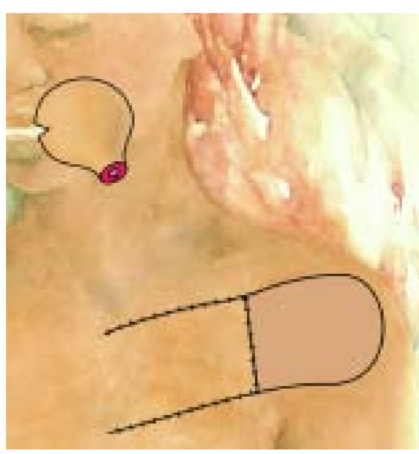

FIGURE 8.26 *Schematic outline of the final stage of a DP flap procedure. The pedicle is transected and returned to the thorax.*

FIGURE 8.27 *Early postoperative result after division of the pedicle of the DP flap.*

V Radial forearm flap **

Introduction

The radial artery and its fasciocutaneous and septocutaneous branches supply virtually the entire skin on the volar and radial aspects of the forearm from the elbow to the wrist, excluding only the skin over the ulna. The well vascularized skin is thin, pliable and makes an excellent flap. The flap can be transferred on a distally or proximally based pedicle. The right choice of pedicle may be very important to avoid tension.

The radial forearm flap is especially useful for reconstruction of large defects and cranially located defects out of range of a DP or pedicled latissimus dorsi flap. In case of concomitant bone loss, vascularized bone may be included in the flap.

Indications

- Large and cranially located defects of the outer cheek (**O**-3,4).
- Large upper-lip defects (**U**-4).
- Upper-lip defects with loss of the premaxilla (**U**-4, **P**: loss of premaxilla) (osteocutaneous flap).

Surgical anatomy

- The brachial artery divides into its two terminal branches, the radial and the ulnar artery, below the elbow crease. The radial artery and concomitant veins run in the lateral intermuscular septum between the brachioradialis and pronator teres muscles in the upper half of the forearm and between the tendons of the brachioradialis and flexor carpi radialis in the lower half of the forearm (Fig. 8.28).
  The artery initially lies deep to the brachioradialis muscle, but its course gradually becomes more superficial.
- The majority of the fasciocutaneous branches originate from the distal half of the radial artery. They run perpendicular to this vessel in the intermuscular septum and form an anastomotic subcutaneous network just above the fascia. These branches can support (almost) the entire skin of the forearm from the elbow to the wrist. The largest of these perforators usually lies 7 to 8 cm proximal to the wrist crease.
- There is a paucity of septocutaneous perforators in the middle third of the forearm where the radial artery lies deep to the brachioradialis muscle (Fig. 8.29).
- The venous plexus is a dual system, with superficial and deep components and numerous anastomoses. The superficial veins communicate with the paired concomitant veins that play an important role in drainage of the distally based radial forearm flap (Fig. 8.30).

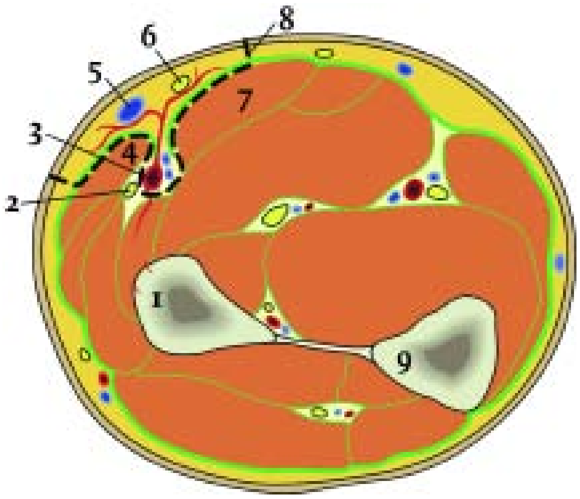

FIGURE 8.28 *Cross-section of the proximal half of the lower arm. Note that the radial artery lies below the brachioradialis muscle at this level and that the plane of dissection lies under the muscle fascia. 1) radius, 2) superficial branch of the radial nerve, 3) radial artery, 4) brachioradialis muscle, 5) cephalic vein, 6) lateral antebrachial cutaneous nerve, 7) flexor carpi radialis muscle, 8) dissection in a subfascial plane, 9) ulna.*

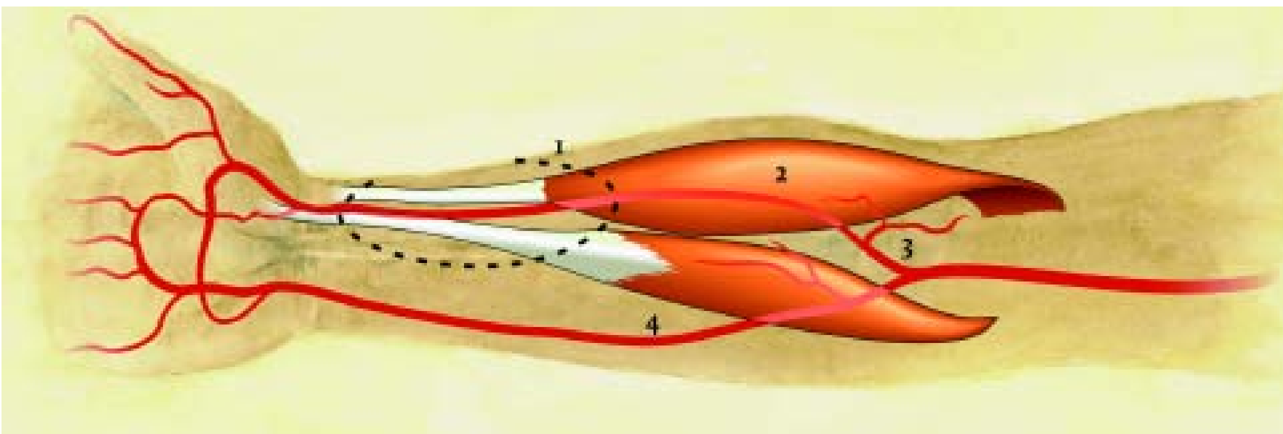

FIGURE 8.29 *The course of the radial and ulnar artery in the forearm. The area containing the main fasciocutaneous branches of the radial artery is encircled. 1) territory of the fasciocutaneous branches from the radial artery, 2) brachioradialis muscle, 3) radial artery, 4) ulnar artery.*

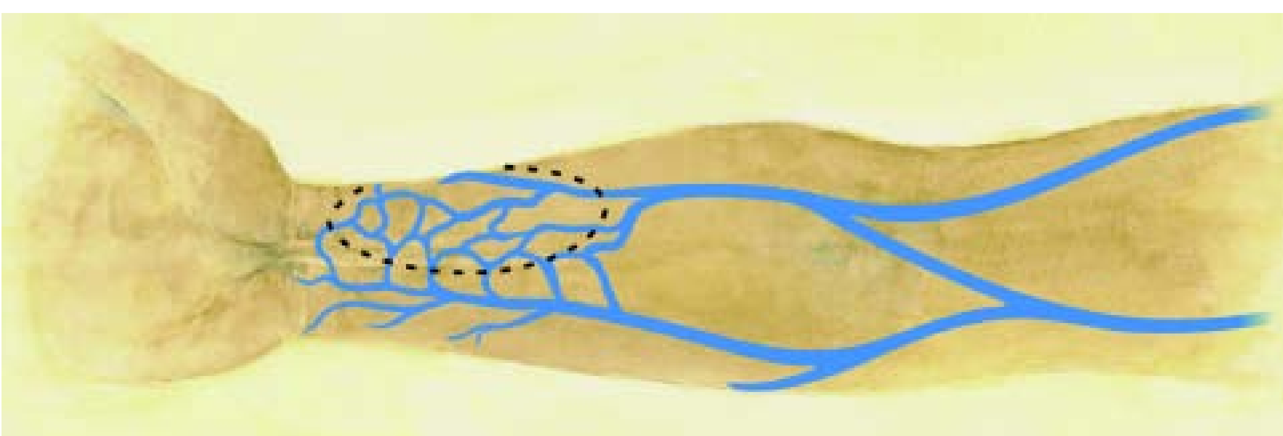

FIGURE 8.30 *The course of the superficial veins of the anterior side of the forearm. The territory of the connections between the concomitant veins and the superficial veins is encircled. These communications play an important role in drainage of the distally based radial forearm flap.*

Surgical technique

First stage (mobilization and transfer)

- Choose the donor arm and decide whether the flap should be proximally or distally based. The position of the arm in relation to the head should be such as to leave the flap absolutely tension-free (Figs. 8.31 and 8.32).
- A preoperative Allen test of both the ulnar and radial artery is essential to establish that the hand will be well vascularized through the ulnar artery (Fig. 8.33).

Proximally based radial forearm flap

- Use a template to draw the estimated outline of the defect (Fig. 8.34).
- Draw a line representing the course of the radial artery from the centre of the antecubital fossa to the point where the radial pulse is felt. This line represents the central axis for the design of the skin flap.
- Design the flap with its distal border extending to within a few centimetres of the wrist joint. Draw parallel lines on both sides of the radial artery from the proximal border of the flap to the antecubital fossa. The skin between these lines becomes the tube of the flap.
- Place a tourniquet around the upper arm after partial exsanguination.
- Incise the margin of the flap and the skin of the intended tube down to and including the deep fascia. Take care to preserve superficial veins.
- Continue the dissection in the subfascial plane (Fig. 8.35). Start the flap dissection at the ulnar border where the fascia is thickest and more easily recognized. Preserve the paratenon investing the flexor tendons in order to provide a suitable surface for a skin graft of the donor site.
- Dissect the flap from the radial side. The tendons of the brachioradialis and flexor carpi radialis can be immediately identified. Ligate and transect the cephalic vein distally. Include the cephalic vein in the flap to provide venous drainage. Isolate and preserve the superficial

FIGURE 8.31 *Schematic representation of a proximally (left) and a distally (right) pedicled radial forearm flap.*

FIGURE 8.32 *This patient was unable to keep his arm high enough during the postoperative period. This should have been tested before the operation. The flap avulsed and the reconstruction failed.*

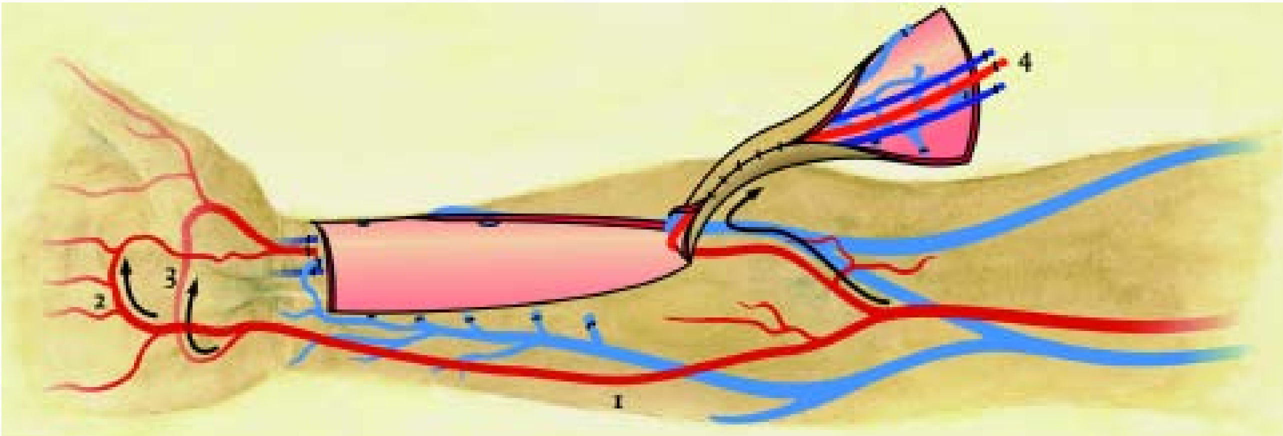

FIGURE 8.33 *Schematic representation of a proximally pedicled radial forearm flap. The vascularity of the hand is supplied by the ulnar artery and the deep and superficial palmar arches. 1) ulnar artery, 2) superficial palmar arch, 3) deep palmar arch, 4) radial artery and concomitant veins.*

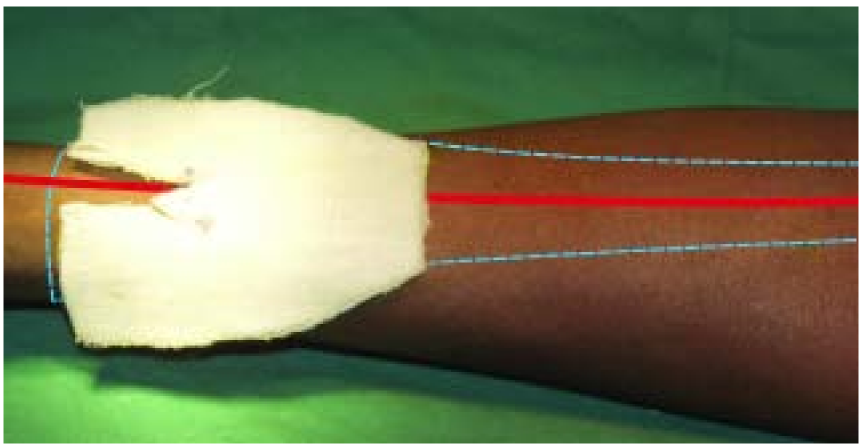

FIGURE 8.34 *A template is used to draw the outline of the flap.*

branch of the radial nerve emerging from the posterior border of the brachioradialis muscle tendon.

- Preserve the septum between the brachioradialis and the flexor carpi radialis where the septocutaneous vessels are contained.
- Isolate the distal end of the radial artery, place a microvascular clamp across it and release the tourniquet to assess the adequacy of the circulation to the hand. Exsanguinate the arm again. Ligate and transect the radial artery and concomitant veins.
- Dissect the radial artery from distal to proximal by transection and (bipolar) cauterization of the deeper branches that supply the muscles of the forearm and the radius.

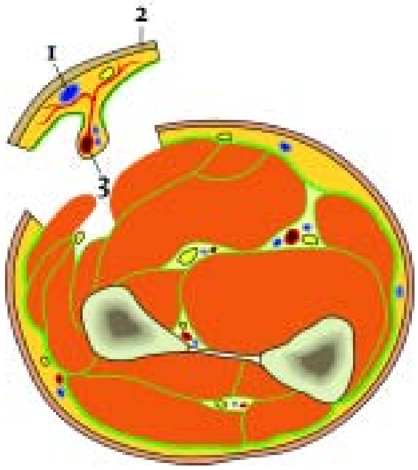

FIGURE 8.35 *Cross-section of the forearm after dissection of a radial forearm flap. Note that subfascial dissection helps to include the radial vessels. 1) cephalic vein, 2) skin paddle, 3) radial artery and concomitant veins.*

FIGURE 8.36 *A proximally based pedicled radial forearm flap designed for reconstruction of the upper and lower lip and cheek ready for transfer.*

FIGURE 8.37 *The same flap transferred and sutured.*

- Expose the radial artery and concomitant veins by retracting the brachioradialis muscle from the flexor carpi radialis muscle. Mobilize the vessels all the way to the bifurcation of the brachial artery and complete flap elevation.
- Release the tourniquet and achieve haemostasis.
- Suture the skin of the tube (Fig. 8.36).
- Close the donor defect by approximation of the skin edges. The remainder of the defect is closed with a split-thickness skin graft.
- Transfer the flap and suture it to the face (Fig. 8.37).
- Fix the arm on the head with broad fixatives and bandages, and keep a close eye on the patient during the period of postoperative unrest (Fig. 8.38).

FIGURE 8.38 *A proximally based radial forearm flap was used for reconstruction of the upper lip. Immobilization of the arm to the head is well accepted.*

Distally based radial forearm flap

- Use a template to draw the estimated outline of the defect.
- Draw a line representing the course of the radial artery from the centre of the antecubital fossa to the point where the radial pulse is felt. This line represents the central axis for the design of the skin flap.
- Design the flap with its proximal border extending to within a few centimetres of the antecubital fossa. Draw parallel lines on both sides of the radial artery from the distal border of the flap to a few centimetres of the wrist. The skin in between these lines becomes the tube of the flap (Fig. 8.39).
- Place a tourniquet at the base of the arm after partial exsanguination.
- Incise the margin of the flap and the skin of the intended tube down to and including the deep fascia. Take care to preserve superficial veins.
- Isolate the proximal end of the radial artery, place a microvascular clamp across it and release the tourniquet to assess the adequacy of the circulation to the hand. Exsanguinate the arm again. Ligate and transect the radial artery and concomitant veins.
- Proceed with the dissection in the subfascial plane from proximal to distal. Expose the radial artery and concomitant veins by retracting the brachioradialis muscle from the flexor carpi radialis muscle.
- The distal pedicle should never be skeletonized, preserving subcutaneous tissues in the region of the wrist to protect the veins that bridge the superficial and deep venous systems.
- Release the tourniquet and achieve haemostasis.
- Suture the skin of the tube.
- Close the donor defect by approximation of the skin edges. The remainder of the defect is closed with a split-thickness skin graft.

Second stage (division of the pedicle)

- It is usually safe to divide the pedicle 5-6 weeks after transfer. If however the surrounding area is severely scarred or the healing process has not proceeded optimally, it is better to wait another week or several weeks. When in doubt, clamp the tube temporarily with a slack bowel clamp and observe the capillary refill.
- Divide the tube, leave enough tissue at the head for inset and observe the back flow.
- If the back flow is good, proceed with the inset. This procedure involves some dissection of the flap back from the initial inset and slight thinning so that the flap fits neatly. If the back flow is slow, postpone the inset for a week.
- Convert the pedicled tube to a flat flap and return it to its preoperative site.

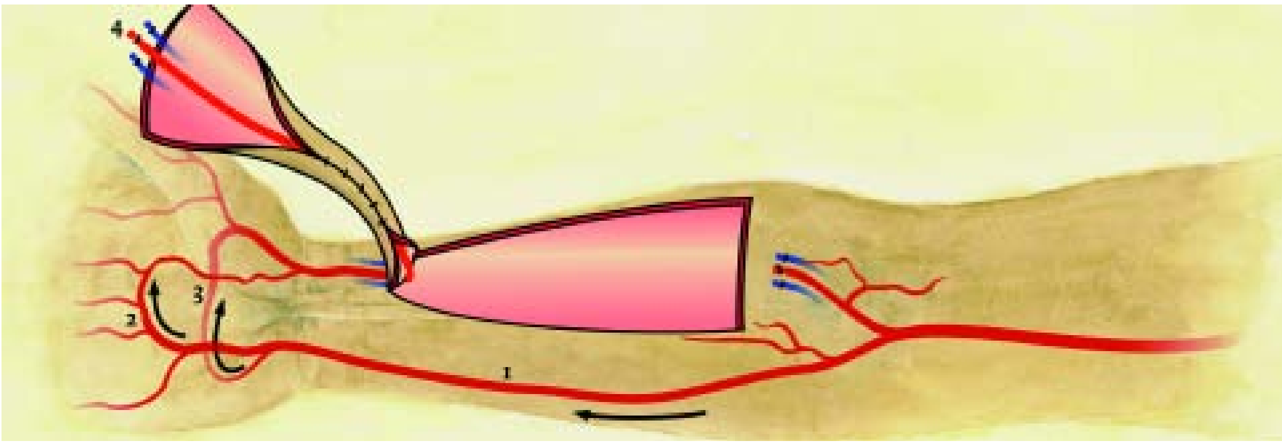

FIGURE 8.39 *Schematic representation of a distally based pedicled radial forearm flap. 1) ulnar artery, 2) superficial palmar arch, 3) deep palmar arch, 4) radial artery and concomitant veins.*

Problems and solutions

- Avulsion of the flap as a result of too much tension on the pedicle. Careful selection of donor arm and pedicle type may avoid this complication.
- Necrosis of the hand due to inadequate collateral circulation through the ulnar artery and palmar arches. The quality of the collateral circulation should be assessed preoperatively with the aid of the Allen test and peroperatively by temporary clamping of the radial artery. If these tests show inadequate circulation, the operation must be cancelled.
- Stiffness or pain of the shoulder. Immobilization of the arm during the recovery period is usually well accepted. Physiotherapy may be necessary to deal with any complaints that arise in this respect.

VI Latissimus dorsi flap ***

The myocutaneous latissimus dorsi flap may be used either pedicled or free. The primary blood supply to the flap is from the thoracodorsal artery and vein, which arise from the subscapular axis supplying a long vascular pedicle. The large skin area of the flap makes it particularly suitable for resurfacing very large defects (Figs. 8.40 and 8.41).

The whole face can be reached by passing the flap through the axilla between the pectoralis minor and major or over the surface of the pectoralis major. Several manoeuvres have been described to enhance the arc of rotation.

For reconstruction of the mucosal lining as well as the skin, the flap may be folded and the intervening bridge de-epithelialized. An alternative solution is the bilobed split latissimus flap (which in essence provides two flaps). A word of caution is needed regarding the weight of this flap, especially when it is folded for coverage of full-thickness defects. Secondary debulking procedures are often needed.

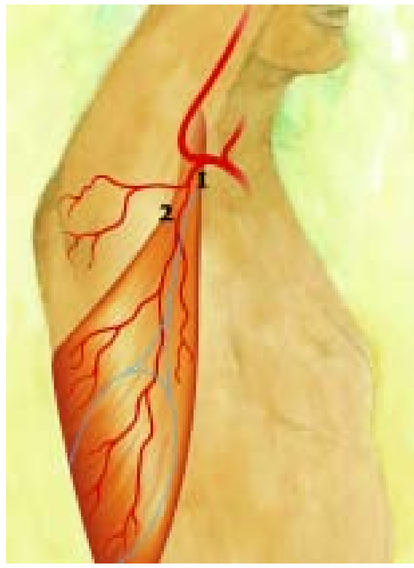

FIGURE 8.40 *The myocutaneous latissimus dorsi island flap showing the arterial blood supply and the outline of the skin island. 1) subscapular artery, 2) thoracodorsal artery.*

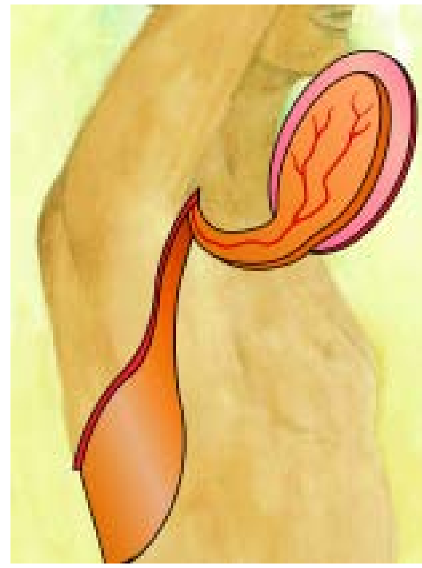

FIGURE 8.41 *The oblique donor site ensures maximal length of the pedicle and hence maximal reach of the flap.*

The latissimus dorsi flap is well known as a safe, reliable solution. Complications like marginal necrosis are usually caused by trying to go beyond the maximum safe size, wrong placement of the skin paddle or compression or stretching of the vascular pedicle.

VII Submental island flap ***

The submental island flap is based on the submental branch of the facial artery and vein, which supply the skin of almost the entire triangle of the neck between the hyoid bone and the mandibular inferior edge, from angle to angle. The flap has a wide arc of rotation. It can reach the whole homolateral section of the face between the forehead and the inferior border of the mandible. The skin matches the colour and texture of the face.

The flap can also be used as an osteocutaneous flap incorporating a rim of the mandible for reconstruction of the premaxilla.

The flap is safe but the dissection is not easy and must be very precise. The surgeon should take care not to separate the skin paddle from the submental vessels and not to injure the marginal mandibular nerve.

FIGURE 8.42 *A free flap may be an attractive alternative in a patient with a complex defect (***N***-2,* **O***-4,* **I***-4,* **T***-3,* **U***-2,* **L***-2,* **P***: loss of maxilla, lower eye lid and part of chin skin) (left). Late result after reconstruction with a free flap (right).*

VIII Free flaps ***

The pedicled locoregional flaps mentioned above suffice to provide a lining for the majority of noma-related defects of minor and intermediate size and even for some quite large ones. There are however some noma patients who present with such complex tissue defects that special measures are needed to deal with them. A free flap may be an attractive alternative in such cases (Fig. 8.42).

The microvascular free flap transfer is often characterized as the measure of last resort. We would disagree with this appraisal. A free flap can be used without restraint when the case and patient profile provide a good indication, the surgeon has the necessary microsurgical experience and the hospital has the infrastructure needed for the operation. Generally speaking, there is no ethical reason why the full spectrum of reconstructive surgery should not be offered to any patient anywhere in the world.

Microsurgery can provide elegant integrative solutions to noma-related reconstructive problems. But remember the general principle that the physician must in the first place avoid all actions that harm the patient. If you or your team do not feel perfectly comfortable with a given operation, do not use it but recheck to see whether other, less far-reaching procedures can help the patient equally well.

The pros and cons of the use of free flaps on noma patients may be summarized as follows.

General advantages

- Flaps of ample size and a sufficient variety of shapes are available.
- Freedom of movement of the head is not restricted by pedicles. There will be no danger of 'pedicle pull-off' (to which children in particular are especially liable).

- One supple, soft skin flap can be used to provide simultaneous closure of inner and outer lining through flap folding (Fig. 8.43).
- Avoidance of further facial scars.
- Distant donor sites allow simultaneous trismus release and flap preparation by two teams.
- No 'swopping' of facial soft tissues but provision of additional volume for secondary reconstruction (especially valuable in treatment of the nose) (see Chapter 9).
- These flaps can provide de-epithelialized, vascularized tissue for interposition arthroplasty if needed (Figs. 8.43 and 8.44).
- Primary closure of the donor site is often possible.

General disadvantages

- Thorough microsurgical routine and specialized equipment are necessary.
- The procedure may last appreciably longer than one not involving microsurgery, leading to fluid and electrolyte shifts, acid-base imbalance, hypothermia and coagulation disturbances.
- Use of a distant donor site may give an inferior colour and texture match.
- Frequent patient monitoring by trained personnel is necessary.
- There is a very small risk of anastomosis rupture with sudden, life-threatening bleeding from neck vessels and airway obstruction by haematoma.
- Free flaps, just like pedicled flaps, may need secondary procedures (debulking, oral commissure reconstruction).

A number of free flaps have proved useful in the treatment of large, complex defects in noma patients. All were used folded and revascularized to the facial, lingual or superior thyroid vessels by a separate incision. They are briefly described below.

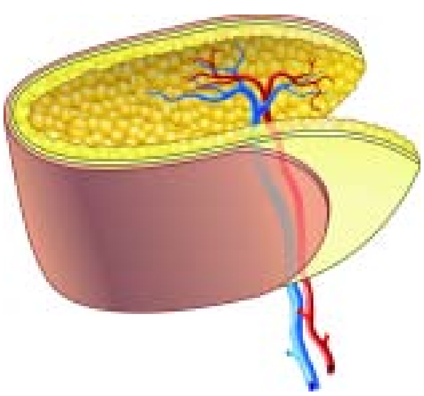

FIGURE 8.43 *Schematic representation of a folded free flap (e.g. a parascapular or anterolateral thigh perforator flap) for combined closure of inner and outer lining. The light area is de-epithelialized and can be interposed between the osteotomized areas after ankylosis release.*

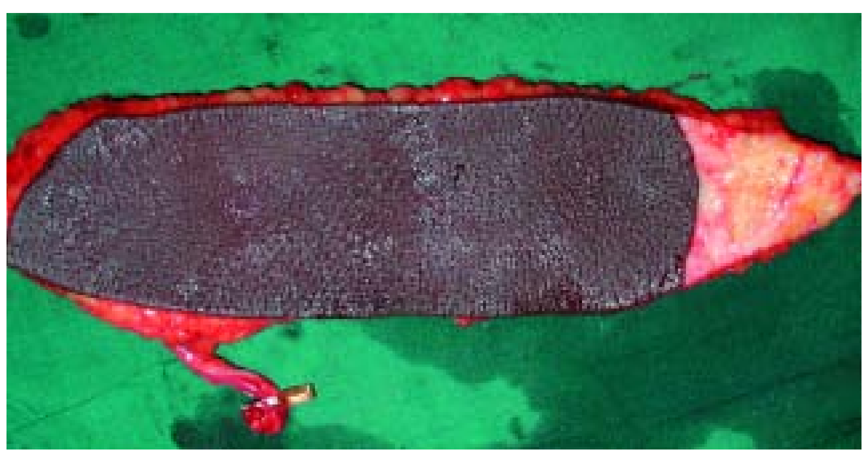

FIGURE 8.44 *A parascapular flap prepared for reconstruction of the inner and outer lining as well as coverage of the osteotomized area of the mandible.*

FIGURE 8.45 *Complete left cheek reconstruction with a free musculocutaneous latissimus dorsi flap two days postoperatively. Note the marked swelling which is still present but will diminish after a few weeks.*

Parascapular flap

This flap is based on the descending branch of the circumflex scapular artery and must be prepared with the patient in the lateral prone position to facilitate recipient vessel dissection in the anterior carotid triangle. Intraoral inset of the flap can however be difficult in this position so repositioning of the patient may be necessary. Almost any flap size is possible, depending on the dimensions of the facial defect. There is a good to acceptable thickness of the subcutaneous fat layer in thin patients. The long pedicle is wide enough (at the site of the subscapular artery) to be anastomosed safely with loupes (providing a magnification of 4.5 x). Primary closure of the donor site is always possible.

Anterolateral thigh perforator flap

This flap can be harvested in a prone position so that there is no need for patient repositioning during the inset procedure. This flap is generally thinner than the parascapular flap. Dissection may be quick if septocutaneous perforators are available, but can be prolonged if one has to rely on myocutaneous vessels. The availability of multiple perforators makes it possible to harvest two separate flaps on one pedicle, thus obviating flap folding. The pedicle may be too small to be anastomosed under loupe magnification in malnourished children. The thin, fragile pedicle of this flap is more susceptible to kinking and, in case of an infection, to septic occlusion than that of the parascapular flap. Primary closure of the donor defect may be difficult if the flap is large.

Radial forearm flap

Dissection of this flap is relatively quick and easy, and can be done simultaneously with surgical procedures in the face like trismus release and recipient vessel dissection. A robust pedicle of ample length and diameter is available. The flap is very thin and may not provide sufficient bulk for the cheek and midface, but is especially useful for total upper-lip reconstruction. Closure of the donor site may be complicated by incomplete skin graft take and tendon exposure. The donor site is constantly visible in typical African attire. A preoperative Allen test is imperative to ensure that blood supply of the whole hand through the ulnar artery is adequate.

Myocutaneous latissimus dorsi flap

This flap has much the same disadvantages as the parascapular flap. It provides bulk for absent midface structures and vascularized tissue to embed titanium mesh for e.g. orbital floor reconstruction (Fig. 8.45). It is often too thick, however, especially if two skin islands are used for reconstruction of the outer and inner linings. Split-thickness skin grafts on this flap have a strong tendency to contract. The flap is heavy and may sag if not properly supported. On the plus side, functional donor site morbidity is negligible.

Reconstruction of central defects (upper lip and nose)

9

Introduction

Gangrene of the midface may affect the medial upper lip, the nose and the underlying skeleton such as the maxilla and the nasal bones. The following simple rules of thumb provide a sound strategic basis for successful reconstruction of these defects.

- Always reconstruct the underlying skeleton (an upper lip needs a premaxilla, and a nose needs projection from bone and cartilage).
- If a defect affects both the upper lip and the nose, always reconstruct the upper lip first and use the reconstructed upper lip with premaxilla as platform for subsequent nose reconstruction.
- Do not begin a reconstruction of a central defect without a clear plan for the **complete** treatment.

Reconstruction of small medial defects of the upper lip may be relatively easy. Sometimes an Abbe flap is feasible. However, it is quite common that the upper-lip defect is too large for this method while also reconstruction of a maxillary defect is required to provide the bony base for a later nose reconstruction. In these cases complex *** reconstructive methods are necessary. The first section of this chapter deals with methods feasible for the reconstruction of the medial upper lip and, if necessary in preparation for a subsequent nose reconstruction, the underlying bone. All of them have been described more extensively in Chapter 7 and 8.

The second, and largest, section of this chapter deals with methods to reconstruct nose defects. For practical reasons, this section is divided into two parts, the first dealing with uncomplicated */** and the second with complex nose reconstruction techniques ***.

Since the gangrene invades the nasal tissues from the mouth, it is obvious that small nasal defects are located in the lower, cartilaginous and mobile part of the nose while larger defects also involve the more cranial (bony) parts. Nasal defects in noma patients are almost always full-thickness with loss of inner lining, skin and the cartilaginous or bony support between these layers. In small defects, like a part of a nostril where most of the nasal skeleton has remained intact, one may confine oneself to reconstruction of the inner and outer lining alone. In large defects reconstruction should always include all three layers involved: the inner lining, the skeleton and the skin. If the skeletal defect is left untreated the soft tissues will easily collapse, leading to an obstructed airway and a poor aesthetic result. These tissues can rarely be expanded once fixed by scarring, so there is little or no scope for subsequent correction of the shape of the nose.

It is also very important to keep in mind that cartilage and bone grafts depend on lining for vascularization and lining depends on cartilaginous or bony grafts for support and contour, so the three should always be used in combination and at the same time.

Inner lining can be provided by various methods. A simple approach is the use of a turnover flap of local skin from the nose or cheek. It is sometimes possible to use a forehead flap by folding it or applying a skin graft to its rear surface a week before the nose reconstruction. The use of two separate medial forehead flaps, one for the inner lining and one for the outer, is only necessary in rare cases.

A part of a pedicled flap like a temporoparietal fascia flap or a part of a free flap may also be used to provide the inner lining under exceptional circumstances.

Skeletal support of the nose can be divided into two components: rigid midline support and flexible lateral airway support. Most defects are located distally and involve cartilage only. Small cartilage grafts can be obtained from a concha. Larger cartilaginous grafts can be harvested from costal cartilage and cortical bone grafts from the iliac crest.

Outer lining is almost always reconstructed with a forehead flap, which is safe, easy to transfer and can give excellent contour and texture matches. Rarely other sources and methods are to be found, like the scalp flap, the Tagliacozzi method or a free flap. Nasolabial flaps might be suitable for reconstruction of the ala or the lining of the columella in isolated cases, but this approach is rarely feasible in noma patients because their nasal defects often coincide with a defect or scarring of the cheek, making it impossible to take a flap from the nasolabial area.

Reconstruction of the upper lip (plus bone)

I Abbe flap (+ crescentic peri-alar cheek advancement) *

Details of the operational procedure may be found in Chapter 7-I (page 57).

II Temporoparietal fascia flap (osteofascial) ***

The surgical anatomy and technique of elevation of the temporoparietal fascia flap are described in Chapter 8-I (page 75). The superficial temporal fascia is connected to the underlying calvarian bone and its periosteum by a fragile layer of loose connective tissue containing blood vessels that supply both the fascia and the periosteum. This makes it possible to include part of the underlying calvarian bone in a temporoparietal fascia flap (Fig. 9.1).

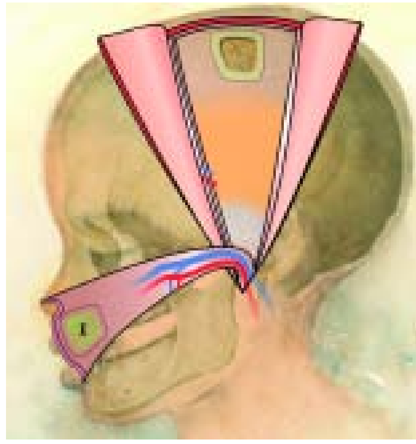

FIGURE 9.1 *Osteofascial temporoparietal flap after raising. Since the connections between fascia and periosteum are very loose and fragile, the part of the flap containing these two layers is made 1 cm wider than the bone itself on all sides. Use only the parietal layer of the calvarian bone. 1) outer table of calvarian bone.*

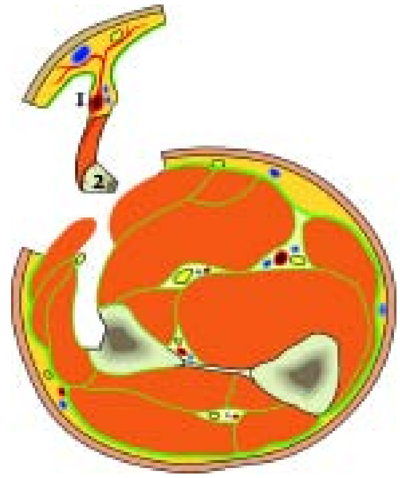

FIGURE 9.2 *Cross-section through the middle part of the forearm, showing the vascular connections between the radial artery and the segment of the radius included in the radial forearm flap. 1) radial artery and concomitant veins, 2) segment of radius.*

The osteofascial temporoparietal flap may be used for reconstruction of the premaxilla, nasal bone, maxilla or palate. It is indicated only for patients older than 10 years because the periosteum-bone connection is too vulnerable in young children and, even more importantly, because the parietal layer of the calvarian bone cannot be separated from the underlying layer in these cases.

III Radial forearm flap (osteocutaneous) ***

The surgical anatomy and technique of elevation of the radial forearm flap are described in Chapter 8-V (page 90). A fragment of bone up to 10 cm long from the anterolateral segment of the radius between the insertion of the pronator teres and brachioradialis muscles can be included in this flap. The blood supply for the periosteum and the underlying cortex is provided by vessels running through the attached flexor pollicis longus muscle (Fig. 9.2). The width of bone must be less than a third of the circumference of the radius in order to minimize the risk of a subsequent fracture of the radius.

The osteocutaneous radial forearm flap can be used for simultaneous reconstruction of the upper lip and underlying premaxilla.

FIGURE 9.3 *A patient with a central defect classified as* **N**-4, **O**-1, **I**-0, **T**-0, **U**-4, **L**-0, **P**: *loss of premaxilla (left). Reconstruction by means of a folded free radial forearm flap. Subunits are used for reconstruction of the columella and both nasal vestibular floors (right).*

IV Submental island flap (osteocutaneous) ***

The surgical anatomy of the submental flap is briefly described in Chapter 8-VII (page 97). This flap can be raised together with a piece of cortical bone measuring 10 x 2 cm taken from the rim of the mandible, with blood supply from small periosteal vessels. Care must be taken not to injure the inferior alveolar nerve.

The osteocutaneous submental flap can be used for simultaneous reconstruction of the upper lip and underlying premaxilla.

V Free flaps (osteocutaneous) ***

Many defects can be closed by advancement and rearrangement of local facial tissue. Unfortunately, this adds further scars to the face and often does not provide enough tissue to build up the necessary solid structural basis for secondary nose reconstruction. Free flaps taken from other parts of the body can provide large amounts of tissue, and avoid additional facial scarring.

The pros and cons of the use of free flaps in noma surgery, and other general considerations, have already been discussed in Chapter 4 (page 38) and 8-VIII (page 98).

Central defects can be satisfactorily closed using a parascapular or radial forearm flap, which can be dissected so as to include bone (from the lateral rim of the scapula or the radius respectively) for premaxilla and nasal floor reconstruction. Both of these flaps can be folded to form an inner and an outer lining, thus avoiding complicated mucosal flaps with secondary scarring in the mouth (Fig. 9.3).

They also have the advantage of a very long pedicle that can bridge the gap between the mid-face and the usual donor vessels in the anterior neck. The parascapular flap provides more bulk than the radial forearm flap, especially in children.

FIGURE 9.4 *Complete loss of premaxilla, upper lip and nose in a five-year-old girl classified as* **N**-4, **O**-1, **I**-1, **T**-0, **U**-4, **L**-0, **P**: *loss of premaxilla (left). Six months after inset of a free osteocutaneous parascapular flap that has been folded and partially de-epithelialized. The volume deficit has been corrected (right). Secondary corrective operations for the nose and mouth are planned.*

Free flaps have the disadvantage that several corrections will probably be necessary to obtain good form and function. They can also result in a significant colour and texture mismatch (Fig. 9.4).

Vascularized bone grafts heal better than non vascularized bone grafts like a rib or an iliac crest graft. Non vascularized bone might be used, though, if it is 'sandwiched' safely and protected from infection in a well vascularized flap. For example, a non vascularized calvarian bone graft (external table) wrapped in a folded radial forearm flap could be used for reconstruction of the nasal floor and bony palate in adults.

Uncomplicated reconstructions of the nose */**

Small nasal defects (**N**-1) are commonly seen at the alar rim, sometimes extending to the side of the nose (**N**-2). Reconstruction of these defects may be not too difficult, provided there is a good base for the new rim. However, many patients with these small nasal defects also have underlying defects like loss of part of the upper lip and the maxilla. In line with the general principles mentioned in de opening lines of this chapter, these problems must be solved first before a nose reconstruction can be considered.

It is not always necessary to reconstruct the (cartilaginous) skeletal support in small nasal defects. A well designed forehead flap, with adequate inherent stiffness of its own, may be sufficient to do the job.

A central defect involving only the membranous septum and the columella with intact skin cover of the nasal tip and a good contour may often be best left untreated. Not all small nasal defects are easy to reconstruct. For example, the columella is just at the limits of reach of all available flaps; multistaged repair with a burrowed superiorly based nasolabial flap is difficult and the final result may be too bulky.

FIGURE 9.5 *Schematic representation of four turnover flaps for reconstruction of the inner lining of the nasal vestibule (left and middle). The flaps are partially scarred. Delay and a wide, thick base are necessary. Secondary defects require closure at the time of reconstruction (right) (see also Figs. 9.12-9.23).*

Inner lining may be provided by many means as outlined in the general introduction above. For practical reasons, we restrict ourselves here to giving details of the local turnover flap and the (prefabricated) medial forehead flap.

Reconstruction of **skeletal support** is not always necessary. However in many cases cartilage grafts are necessary to support the septum, a nasal ala or to reinforce the base of a nasal rim. A good donor site for such a graft is the concha. Cartilage grafts are sutured to the underlying raw surfaces of the lining flaps.

Outer lining is almost always provided by a medial forehead flap, which is described in detail hereafter.

VI Local turnover flap *

Introduction

The site of a local turnover flap is chosen immediately adjacent to the defect to be repaired (Fig. 9.5). Since the hinge around which the flap is turned is the scar of the skin-mucosal connection and the blood supply across such a scar is seldom good, the flap should be planned as short as possible. It may be possible to reduce the length of the flap by designing two short flaps on opposite sides of the defect. Also a delay prior to application of the flap will make the procedure safer.

The donor defects of this lining flaps will influence the size and design of the skin flap used to reconstruct the nasal skin.

Surgical technique

- Mark the outline of the planned flaps.
- Inject adrenaline solution around the flaps and wait for 5 minutes.

- Raise the flaps and incorporate as much of the deeper tissue as will still allow the flap to hinge. Check the blood supply of the flaps.
- It is better to shorten the flaps in an area of doubtful circulation as long as the quality of the reconstructed airway is sufficient. This helps to avoid serious loss of framework support and airway stenosis due to necrosis and infection of parts of these lining flaps.
- Suture the flaps with absorbable material and check (once) again their blood supply.

Fig. 9.6 illustrates the reconstruction of the inner lining in a patient with an **N-3** defect with a prefabricated medial forehead flap.

FIGURE 9.6 *A patient with a defect on the side of the nose (***N**-*3*, **O**-1, **I**-0, **T**-0, **U**-0, **L**-0, **P**-0*). A medial forehead flap, skin grafted one week previously, was raised and transferred to provide the inner and the outer lining of the nose. The defect was closed but the external appearance was not significantly improved and the function of the airway deteriorated. Inclusion of cartilage for skeletal support would have been a far better solution.*

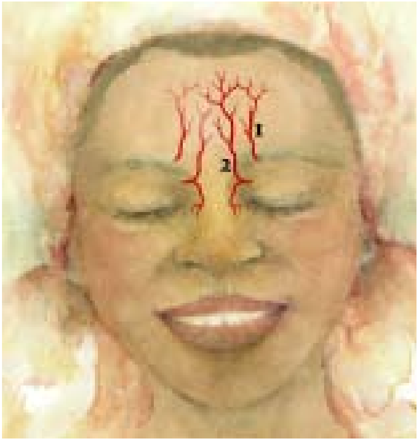

FIGURE 9.7 *Schematic outline of the vascular anatomy of the medial forehead. 1) supraorbital artery, 2) supratrochlear artery.*

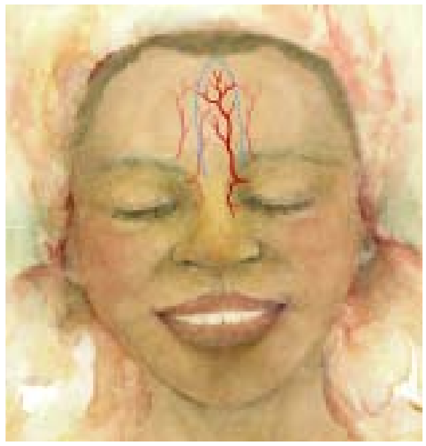

FIGURE 9.8 *Schematic outline of a small medial forehead flap based on the left supratrochlear artery.*

VII Medial forehead flap *

Introduction

A medial forehead flap is the method of choice to repair nasal skin defects. This flap has been used for this purpose since many centuries. The flap is reliable and a delay procedure is not necessary.

This flap can be used in different ways. In small reconstructions one may consider prefabrication by applying a skin graft and, if necessary, a cartilage skeletal support one week prior to transposition. The deep surface of the flap is (subsequently) used to provide the inner lining, and the superficial surface to provide the skin.

Surgical anatomy

- The flap may be midline, paramedian or oblique. The oblique flap is mainly used if greater flap length is desired, e.g. if the frontal hairline is low or particularly for nasal tip and columella reconstruction.
- The forehead flap is based on the supraorbital and/or supratrochlear vessels on one side. Both arteries are branches of the ophthalmic artery. The supraorbital vessels exit at the supraorbital notch, and the supratrochlear vessels at the superior edge of the medial canthal ligament (Fig. 9.7).
- Doppler sonography may be useful to confirm the location and patency of the arteries, especially in the presence of scars medial to the eyebrow. The supratrochlear artery runs approximately 2 cm and the supraorbital artery approximately 2.9 cm from the midline. Exact localization of the vertically oriented blood vessels allows a very narrow pedicle to be created. The vessels are generally not dissected out at the base, where they lie deep within the frontalis and corrugator muscles. They rise rapidly in the distal part of their course, and lie in the subcutaneous fat below the dermis near the hairline. This superficial location permits aggressive thinning of the distal part of the flap in the interest of debulking.

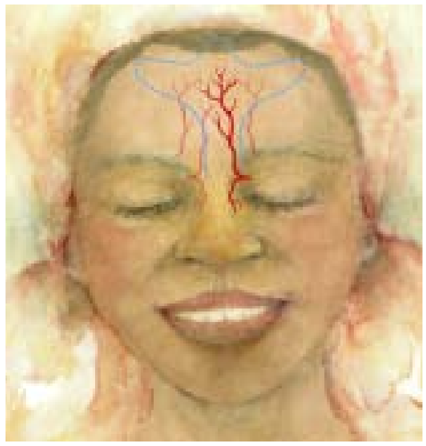

FIGURE 9.9 *Schematic outline of a large medial forehead flap based on the left supra-trochlear artery for reconstruction of the nose including the dorsum, tip, columella and lateral wings.*

FIGURE 9.10 *Schematic outline of the transfer of the medial forehead flap.*

Surgical technique

First stage (mobilization and transfer)

- Make an exact three-dimensional template of the defect. When designing the template, one should bear in mind that the skin of the flap should not be sutured under any tension whatsoever, either at the alar rim or at its most distal rim as part of a columella reconstruction. Minor stresses can lead to major complications later. Always add 1-2 millimetres extra at each side for the fact that the flap is thicker than the template. The base is traced directly above the root of the nose and overlies the donor vessels. The proximal two-thirds of the flap and its base are narrow while the upper third widens rapidly (Figs. 9.9 and 9.10).
- A narrow pedicle permits easy rotation without strangulation, does not distort the eyebrow on closure and does not need to be replaced to the forehead at the time of pedicle division.
- Inject adrenaline solution around the distal part of the flap. Wait for 5 minutes.
- Assess whether the flap is long enough with the aid of the template, or preferably using a piece of gauze. If additional length is needed one can elongate the pedicle proximally by means of an incision that goes no deeper than the skin, or extend the flap into the hair-bearing scalp.
- The pedicle should be long enough not to exert cephalad tension on the nasal tip. This would give rise to an unattractive snub nose that is frozen in place due to scarring before the tension can be released by transection of the pedicle.
- Hair follicles can be removed with sharp-tipped scissors under loup magnification, but this should be done with caution in the most distal 5 mm of the flap. Complete hair removal creates the risk of disastrous necrosis in the columellar base and the alar rim. Exposure of cartilage at these locations means loss of the reconstruction, as no secondary healing can be expected here.

FIGURE 9.11 *Alar reconstruction using a folded medial forehead flap in a patient with a classification* **N**-1, **O**-2, **I**-2, **T**-2, **U**-2, **L**-0, **P**-0 *(left). The inner lining of the cheek has been reconstructed with a local transposition flap and the outer lining of the cheek with a DP flap (right).*

- Elevate the flap distally superficial to the frontalis muscle, but include the muscle with the pedicle proximally to protect the blood vessels.
- Thanks to the excellent blood supply, the distal 2-3 centimetres of the flap can be thinned to the superficial fatty tissue.
- Rotate the flap 180° to the nasal defect and suture it directly in place (Fig. 9.10).
- The pedicle can be covered either with a split-thickness skin graft or a skin substitute like Epigard. The latter will cause the pedicle to tube spontaneously. Care must be taken not to compromise the pedicle by inappropriate covering or dressing techniques.
- Close the forehead donor site by undermining the subfrontalis layers. A gap will often remain high on the forehead below the hairline. Secondary healing will give a better appearance here than a skin graft or suturing under appreciable tension (see page 116, Fig. 9.22 and page 117, Fig. 9.23).
- Vestibular sponge packing or silicone stenting is necessary for 4-6 weeks.

Fig. 9.11 illustrates the reconstruction of an **N**-1 defect with a folded medial forehead flap (combined with reconstruction of the outer lining of the cheek using a deltopectoral flap).

Second and third stages (debulking, division of the pedicle and refinement)

- The need for, and feasibility of, a debulking procedure must first be determined. This is mostly a question of patient compliance, which may be reduced after months in hospital. On the other hand, the need for an aesthetically pleasing result is the same in Africa as it is in Europe.
  Early debulking, while the pedicle is still intact, may be better than waiting half a year or more. Late secondary debulking after division of the pedicle leads to a higher risk of vascular compromise and requires smaller surgical steps – a drawback for the patient.
- The use of a folded forehead flap to provide the lining of the vestibules may cause vestibular obstruction. The (distal) folded part of the flap should be debulked by means of an incision

in the alar rim. The blood supply to the distal part will then be completely dependent on the regenerated vessels at its margin, and could be seriously compromised. Late debulking (at least half a year later) may thus be better under these circumstances.

- The columella and alar rims can be subjected to depilation.
- The pedicle may be divided 3-4 weeks after flap transfer, by unrolling the proximal base and excising excess tissue. For the sake of symmetry of the eyebrows, insert the pedicle as a small inverted 'V' only at eyebrow level. Excess pedicle should be discarded rather than leaving an obvious flap in the forehead.
- The forehead scar can be partially reopened to adjust the vertical position of the eyebrow. Any area of secondary healing should be narrowed as far as possible or totally excised and closed.

Problems and solutions

- A portion of the flap may be lost due to inadequate design, tension on the flap, haematoma formation or excessive thinning.
- The inner lining may be compromised by inadequate transfixing sutures and tight nasal packing.

Little can be done to solve these problems once they arise. The only solution is improved planning in subsequent operations.

Complex reconstructions of the nose ***

Introduction

Complex nose reconstructions are required in noma patients to deal with subtotal and total nose defects (**N**-3,4). These defects are often combined with subtotal or total defects of the upper lip and absent premaxilla or adjacent defects of the cheek, lower lid and orbita. All efforts should be made not only to reconstruct the external appearance of the nose but also to restore its function.

This work, involving e.g. use of a second forehead flap for reconstruction of the lining, re-establishment of the whole skeleton of the nose with cartilage grafts and even alternative approaches to skin reconstruction like the use of free flaps, requires great skill and experience and should not be embarked on unless the surgeon is sure he is up to the job.

Surgical techniques

The principal elements of nasal reconstruction are a platform, adequate lining, skeletal support and skin cover. The main lines of the surgical techniques required are described below.

A few preliminary remarks about timing are perhaps in place here. As mentioned above, reconstruction of the upper lip and underlying bone to provide a platform for nose reconstruction should always precede the other phases. It is advisable to wait for a few months after work on the platform, if possible, to allow healing to take place before going on to the nose reconstruction.

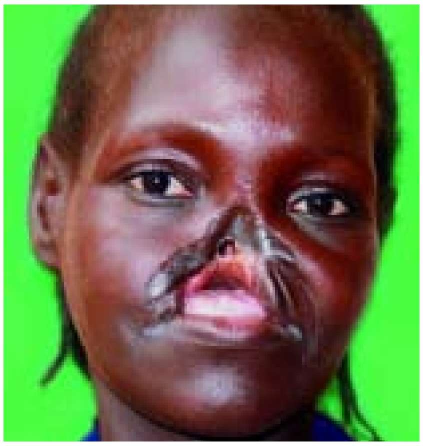

FIGURE 9.12 *A patient with a central defect classified as* **N**-4, **O**-1, **I**-0, **T**-0, **U**-4, **L**-0, **P**: *loss of premaxilla. The upper lip and premaxilla were reconstructed first, and the nose later.*

FIGURE 9.13 *In the same patient the upper lip and premaxilla were reconstructed with the aid of a proximally based osteocutaneous radial forearm flap to provide a platform for nose reconstruction (left). The patient is now ready for nose reconstruction (right).*

For the sake of clarity, it is worthwhile to mention again that cartilage grafts depend on lining for vascularization and lining depends on cartilage grafts for support and contour, so the two should be combined. Lining, skeletal support and skin cover will all be provided in a single operation that may be expected to last many hours.

Platform

The intended nose reconstruction will be based on a platform of maxillary bone, upper lip, nasal floor and excess tissue at the side walls. In the case of severe central defects, these structures must be created in previous procedures. Thus the surgeons who do the first reconstructive work on lips and cheek, should have a proper understanding of the type and position of tissues crucial for later nasal inner lining and skeletal support.

When upper-lip reconstruction has to be combined with reconstruction of a premaxilla defect, the required bone can generally be obtained using either a vascularized bone graft or a nonvascular graft (calvarian bone) totally covered by a highly vascular soft tissue flap.

Fig. 9.12 shows a patient where complex nose reconstruction is indicated. As will be seen, there is also involvement of the upper lip and maxilla in this case, and complex, multistage surgery is required to achieve proper results. Attempts to reconstruct the upper lip and nose with a single flap are highly inadvisable. The reconstruction of the upper lip and premaxilla of this patient is illustrated in Fig. 9.13.

The remaining photos in this chapter all illustrate successive stages of the reconstruction of the nose of the same patient. Fig. 9.14 shows how the use of turnover flaps for reconstruction of the inner lining creates a lateral skin defect. It is thus important to bear in mind that the technique used for cheek reconstruction should bring a great surplus of skin to the nasal area.

FIGURE 9.14 *Use of four (delayed) turnover flaps to provide inner lining. Their donordefects were reconstructed by medial advancement of the skin of the cheek.*

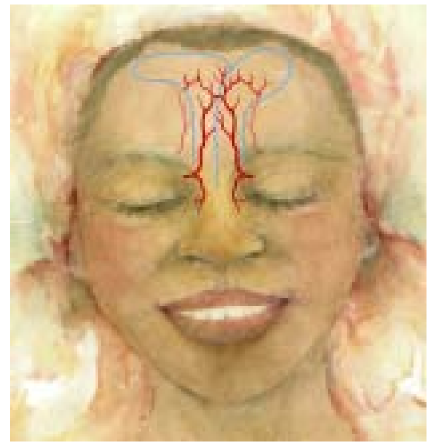

FIGURE 9.15 *Schematic representation of the outline of two forehead flaps, one for inner lining, one for nasal skin. Both flaps are based on a supratrochlear artery.*

Inner lining

A completely closed inner lining is crucial, as no secondary healing can be expected on the surface of the reconstructed supporting framework.

The defect in the lining can be repaired using a combination of local turnover flaps, a forehead flap (in addition to that used for the skin of the nose) and, hardly ever, a temporoparietal fascia flap or a free flap. Sufficient turnover flaps are not always available, in particular if previous reconstructions failed to supply this specific deficiency.

Provision of a complete lining for the columella strut is a demanding task. This particular lining cannot be reconstructed by laterally based turnover flaps, but a turnover flap from the central part of a reconstructed upper lip is an option. When the nasal reconstruction is preceded by upper lip reconstruction, columella lining can be restored by an extended Abbe flap. This may allow for a non-hair-bearing columella. Turbinate mucosa flaps are not reliable for columella lining and oral mucosa flaps are not available in noma patients with central defects.

A second forehead flap is a reasonable alternative (Fig. 9.15). However if the use of a medial forehead flap is considered for the inner lining, it should be realized that the aesthetically more important forehead flap for the nasal skin has priority.

A disadvantage of using two forehead flaps is that primary closure of the donor site will never be possible. The defect will be too large and skin grafting becomes necessary. It should also be realized that the distal end of this flap may be hirsute. The patient can cope with this in the vestibular lining, but hair growth on a reconstructed columella should be avoided.

The forehead flap used for lining can receive its blood supply either from the contralateral supratrochlear vessels if available or via the nearest supraorbital pedicle. The supratrochlear-based forehead flap is superior because the pedicle is closer to the nose and has a greater arc of rotation. The pedicle should be dissected first and not at the same time as the outer lining flap. Creating a passage into the nose for this flap is technically demanding. Tunnelling from the

FIGURE 9.16 *A preoperative design for a cartilaginous substitute for the nasal spine (left). A template is used to shape the rib cartilage properly (middle). This 'cartilage for nasal spine' is fixed in place with a stainless-steel cerclage (right).*

brow into the nasal cavity tends to give rise to a fistula. This can be prevented by de-epithelializing the pedicle in the tunnel, but care must be taken not to compromise the vascularization of the flap.

A forehead flap used for the lining needs immediate debulking in the vestibular area, since subsequent debulking is difficult. The cartilage should be kept wet during this prolonged procedure.

Skeletal support

Skeletal support of the nose can be divided into rigid midline support and flexible lateral airway support. Rib cartilage is the best framework material for total nasal reconstruction. An L-shaped strut provides rigid support for the dorsum and nasal tip in terms of length and height and resistance against cephalad contracture by the forehead flap as long as it is pedicled to the brow. The long arm of the L provides support for the dorsum, while the short arm acts as a columella strut. The L-strut as a whole is fixed to the nasal bones at its upper end, and at its lower end to the anterior nasal spine or its bony substitute if available. Otherwise a cartilaginous substitute must be created. The template for harvest of the cartilage used for this purpose can be drawn on X-ray film, which has the advantages of being transparent and easily cut (Fig. 9.16).

The graft should fit perfectly on the maxilla at the site normally occupied by the anterior nasal spine, and should be fixed rigidly in place and precisely covered by palatal and alveolar mucosa. To avoid slackening due to chewing motions in the immediately postoperative period, the patient should be kept on liquid food for a few weeks to enhance rigid scar formation. Experience shows that this 'cartilage for nasal spine' method works well as a short-term solution in complex nasal reconstructions, but the long-term outcome is not yet known.

The cartilage for the L-strut should be taken from the 6th or 7th rib, including the angle at the synchondrosis if it is in an appropriate plane. This permits creation of two ideally shaped components – the columella strut and the dorsal graft, the two being joined by nylon sutures.

FIGURE 9.17 *The columella strut has been shaped precisely with a small peg at its base that fits into a hole in the 'cartilage for nasal spine' to ensure rigid fixation.*

FIGURE 9.18 *Cartilage grafts for alar support are sutured to the columella strut (left) and to the dorsal graft (right). Additional grafts support the side walls of the nostrils to ensure that the vestibular arches are wide enough.*

The physiological properties of the cartilage do not allow it to be cut into the required L shape, so a two-part graft should be prepared.
Precise shaping and rigid fixation of the graft on to the anterior nasal spine or its replacement and the nasal bones is essential (Fig. 9.17).

After the shaping and fixation of the L-strut are completed, the cartilage grafts used for alar support should be cut to build the vestibular arches ensuring breathing competence (Fig. 9.18). These grafts should be long enough to provide alar support from the alar base or even the pyriform aperture up to the nasal tip. It is therefore advisable to harvest an extra piece of cartilage with this eventuality in mind. Additional split cartilage chips (may) support the side walls as a supplement to the dorsal component of the L-strut and fill dead spaces.

Skin

Reconstruction of the overlying skin of a subtotal or total nose defect is relatively easy and can be done with a forehead flap. It is essential to obtain a flap that is long enough to provide a columella of adequate length and to avoid tension. Sufficient flap size must be planned to make up for anterior nasal lining deficiencies. The folded skin provides the lining of new vestibules ensuring adequate airways, and prevents stenosis.

The central vertical component is used to resurface the dorsum, tip and columella and the lateral wings to wrap around the ala and, if necessary, to curve into the nostril floor and alar base (Figs. 9.19 and 9.20).

The reconstructed alar rim lining can be made thin enough with a forehead flap extension up to 1 cm in length. Columellar and anterior septal lining can also be reconstructed by flap extensions but the columella replacement should not consist of hirsute skin (Figs. 9.21 and 9.22). The distal, folded, part of the flap is usually debulked via a rim incision; this should be done at least half a year later (see also pages 110 and 111).

FIGURE 9.19 *A template is used to design the forehead flap precisely. Note the contours of the flap necessary to shape the nostrils and the columella.*

FIGURE 9.20 *The flap is raised in a subcutaneous plane distally and underneath the frontalis muscle proximally.*

FIGURE 9.21 *The thinned distal end of the forehead flap is used to reconstruct the columella. Hair follicles are removed where necessary.*

FIGURE 9.22 *The flap has been transferred and sutured. The pedicle will be divided at a later stage. The donor defect has been reduced and will close by secondary healing.*

Fig. 9.23 shows the result of the total nose reconstruction six weeks postoperatively.

Postoperative treatment

Daily wound care with cleaning of crusts and application of Betadine solution or antibiotic ointment in the first postoperative days help to avoid complications.

Very careful nasal packing with strips, sponge or vaseline gauze may avoid damage to the reconstructed inner lining and prevent swelling, fibrosis and nasal obstruction. It is helpful to use a head light and suction devices to facilitate this procedure.

FIGURE 9.23 *Result of the total nose reconstruction six weeks postoperatively after division and inset of the pedicle of the forehead flap.*

Patient instruction

The patient should be shown how to clean the nose by ointment application, irrigation and use of cotton tips. Airway obstruction can generally be cleared with small pieces of sponge soaked in olive oil manipulated with the aid of a blunt-tipped forceps. Patients learn the technique very quickly, as they appreciate being able to breathe through their nose after the obstruction has been removed.

The use of stents to keep the airways open may be considered. However, they can cause pressure sores and must initially be applied for no more than 1-2 hours at a time under precise control. If no adverse signs are observed, the application time may be increased, e.g. to 3-4 hours. In the interest of safety, the patient should be instructed not to keep the stents in after discharge for longer than the maximum period used in hospital.

Finally, the patient should be informed that swelling and scar contracture are likely to persist for at least half a year.

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