The Facial Nerve

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OXFORD
OXFORD UNIVERSITY PRESS
NEW YORK TORONTO
1979

Oxford University Press, Walton Street, Oxford OP2 6DP

OXFORD LONDON GLASGOW NEW YORK
TORONTO MELBOURNE WELLINGTON CAPE TOWN
IBADAN NAIROBI DAR ES SALAAM LUSAKA ADDIS ABABA
KUALA LUMPUR SINGAPORE JAKARTA HONG KONG TOKYO
DELHI BOMBAY CALCUTTA MADRAS KARACHI

ISBN 0 19 261128 3

British Library Cataloguing in Publication Data
Diamond, Charles
The facial nerve. – (Oxford medical publications).
1. Facial nerve – Diseases
I. Title II. Frew, Ivor III. Series
616.8′7 RC418 78-40315
ISBN 0-19-261128-3

TYPESET BY ENSET LTD., MIDSOMER NORTON, BATH, AVON.
PRINTED IN GREAT BRITAIN BY
J. W. ARROWSMITH LTD., BRISTOL

TO OUR WIVES

Preface

DISEASES involving the facial nerve present problems to doctors in all branches of medicine. Information on the facial nerve is scattered throughout the textbooks and journals of many different specialities. No comprehensive book dealing with all aspects of the nerve exists, and this volume has been written in an attempt to fill that gap. The book has given us the opportunity of taking a fresh and critical look at the anatomy of the nerve, at the aetiology of Bell's palsy, and also at the vexed question of surgical treatment.

The book is not designed for the exclusive benefit of a single speciality. We hope that the chapter on trauma will satisfy physicians, and that the surgical treatment will be sufficient for the needs of neurologists. If our surgical colleagues find the sections on electrophysiology and medical diseases of the seventh nerve adequate for their purposes, we shall be more than satisfied.

The allocation of the chapters has been governed by the interest and experience of each author, and the opinions expressed in each chapter are those of the writer of that chapter.

Gathering the information for this book has been a very enjoyable and instructive experience. We hope that clinicians, for whom this volume is intended, will find as much pleasure in reading it as we had in writing it.

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Acknowledgements

WE are indebted to the Department of Neuro-radiology at Newcastle General Hospital for the radiographs. Dr Singh and Mr East, F.R.C.S., also provided a photograph, and temporal bone dissections.

Dr D. Barwick, Consultant Neurologist at Newcastle General Hospital, very kindly read the section on electrical testing of the facial nerve, and we are grateful for the advice he gave us. We are also indebted to him for providing Figs 4.2, 4.6, 6.5, and 6.6. We would also like to express our thanks to Dr W. Sandford who read part of the manuscript.

Our work has been greatly facilitated by Miss Emmerson and her staff at the Newcastle University Library, and by Mrs Jeffries and her team in the Medical Library of Newcastle General Hospital. The Department of Photography at the Medical School produced our clinical photographs. To all those who have helped us, we express our sincere thanks.

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General introduction

THE ANATOMY of the facial nerve is particularly interesting because this nerve has the longest and most tortuous course in bone of any cranial nerve, and also because it subserves a variety of functions. These functions have been the subject of debate over the years and some areas of uncertainty still persist. The distinction between the sensory nerve of the face (fifth cranial nerve) and the motor nerve of the face (seventh cranial nerve) was established by Sir Charles Bell (1821, 1829). He held the view that facial nerve function was principally respiratory and called it 'the respiratory nerve of the face'. This fitted in with his concept of the phrenic nerve as the 'great internal respiratory nerve' and the nerve to serratus anterior as the 'great external respiratory nerve'. Indeed this latter nerve is still called the long thoracic nerve of Bell. By establishing that the principal function of the nerve was motor, he helped to end the practice, prevalent at that time, of cutting the facial nerve for relief of tic douloureux.

The facial nerve has two motor or efferent components. The greater part of the nerve is composed of motor fibres to the muscles of facial expression, and in addition the nerve carries secretomotor fibres for the submandibular and sublingual salivary glands and the lacrimal gland. The facial nerve also has two sensory or afferent components. One carries taste sensation from the tongue and palate, and the other carries ordinary sensation from the skin in the region of the external ear.

Embryological considerations

Course of the motor root in the pons

The complex meandering of the motor fibres in the pons can be understood only in the light of the embryological development of the facial nucleus. The nucleus initially lies in the floor of the fourth ventricle, rostral or cephalic to the sixth nerve nucleus. After the fibres from the facial nucleus have been established, the nucleus undergoes a migration. Nerve cells can migrate only by lengthening their axons and the axons therefore trace the path taken by the nucleus from its original to its definitive position. The facial nucleus at first moves caudally and dorsally to the abducens nucleus, and then ventrally to reach its final position.

Some authors attempt to explain this migration by the theory of neurobiotaxis. According to this theory, the nucleus tends to remain as close as possible to its predominant source of stimulation and will migrate in the direction from which the greatest density of stimuli originate. On this basis, the facial nucleus is deemed to be attracted towards the spinal tract of the trigeminal and its nucleus. The abducens nucleus is drawn forward towards the position occupied by the other eye muscle nuclei and it carries the facial root fibres in front of it as it advances. In the opinion of Crosby and de Jonge (1963), the genu is formed in this way.

The theory of neurobiotaxis is not universally accepted, however, and many authors hold the view that this migration may be more apparent than

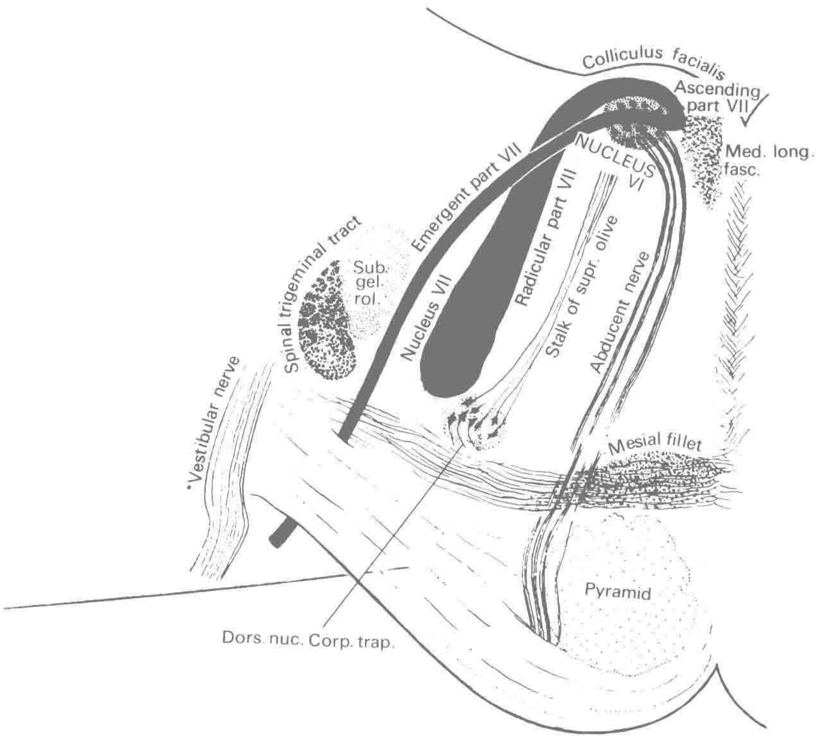

Fig. 1.1. Diagram of intrapontine course of facial nerve, seen from above. Sub.Gel.Rol. =nucleus of spinal trigeminal tract. (Romanes 1972)

real, and may merely be the result of differential growth patterns and displacement rather than active migration (Fig. 1.1). Be that as it may, this migration of the nucleus, whether active or passive, accounts for the highly unusual course of the facial motor root fibres in the pons.

Branchial arch system

By the fifth week of intra-uterine life the human embryo has a well-developed system of external branchial arches and grooves which will eventually intervene between the mouth and the thorax. These external branchial grooves are matched by a similar series of internal pharyngeal pouches (Fig. 1.2(a)). In fish, slits appear in the grooves and pouches to form the gill slits. In amphibia these openings disappear at metamorphosis. In humans the arches are present only in the embryo. Communication between groove and pouch does not take place, and the two remain separated by a layer of ectoderm externally, a layer of endoderm internally, and some mesenchymal tissue sandwiched between these two layers. The muscles of mastication are derived from the first (mandibular) arch, and its principal nerve is the mandibular division of the trigeminal. The muscles of facial expression originate from the second (hyoid) arch, and the nerve of the second arch is the facial nerve. Each arch also receives a branch from the nerve of the arch caudal to it. Thus the first arch receives a branch from the second arch nerve, the second arch receives a branch from the third arch nerve, and so on. These branches must cross over the branchial groove (*trema*: a cleft) separating the two arches and ultimately come to lie in front of that groove (pretrematic branch). The chorda tympani nerve is the pretrematic nerve of the first arch, and Jacobsen's nerve (tympanic branch of the glossopharyngeal nerve) is the pretrematic branch of the second arch (Fig. 1.2(b)). This explains why in the adult the chorda tympani nerve leaves the facial nerve to loop over the tympanic cavity (which incorporates the first pouch) to join the lingual division of the mandibular nerve.

There tends to be a distinct relationship between the nerve of an arch and the arch cartilage. The nerve descends into the arch posterior to the cartilage and then turns forward round its lateral aspect to reach the front of the arch. This relationship persists in the course of the facial nerve in the adult human where the nerve descends posterior both to the stapes and the styloid process and then reaches the facial muscles, by turning forward over the lateral aspect of the styloid. The stapes and styloid process are both derivatives of the second arch cartilage.

Relationship to the parotid gland

An interesting argument exists over the relationship of the facial nerve to the parotid gland. Bailey (1941, 1947) strongly advocated the view that the

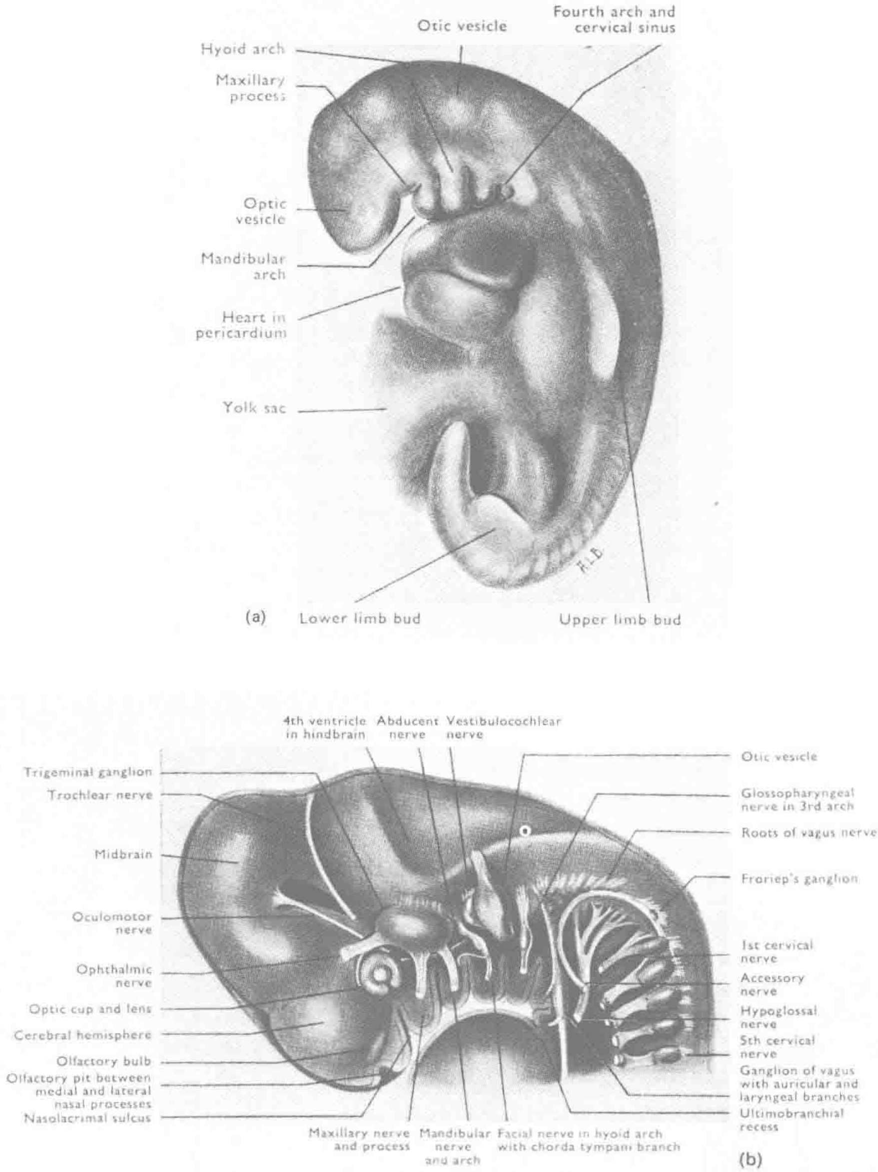

Fig. 1.2. (a) Head end of 5·3 mm long human embryo to show the development of the branchial arches. (Romanes 1972)
(b) Developmental arrangement of the cranial nerves. (Romanes 1972)

gland is a simple bilobed structure united by a single isthmus, which contains all the ducts that pass between the two lobes. According to him, the temporofacial and cervicofacial trunks embrace the isthmus and no part of the facial nerve runs actually in the gland substance. Instead all the branches lie in a plane between the two lobes. He vividly described this arrangement of the nerve in the gland as 'the meat in a parotid sandwich'. He stated that 'the anatomical classics are inaccurate in their descriptions of the facial nerve' and that the nerve does not plunge into the main body of the gland and then divide within the parenchyma as it is traditionally reputed to do. He claimed that surgical enterprise in the parotid region had been stultified by anatomical teaching, and he begged contemporary anatomists, 'to revise their teaching and alter their textbooks'. He was supported by McCormack *et al.* (1945), who carried out over a hundred parotid dissections in cadavers, and by the anatomists Hamilton and Harrison who wrote in Scott-Brown's *Diseases of the ear, nose and throat* (1971), 'The parotid gland is divided into two lobes, a superficial lobe and a deep lobe, by the main branches of the facial nerve which pass through it in a fascial plane'. If this is true, then surgical removal of the parotid gland with preservation of the facial nerve ought to be a very simple matter.

However, Patey and Ranger (1957), in their cadaver dissections, found no evidence to support the bilobar concept of the parotid gland. In an elegant experiment, McKenzie (1948) injected the parotid duct system of anatomical specimens and demonstrated that ducts passed between the superficial and

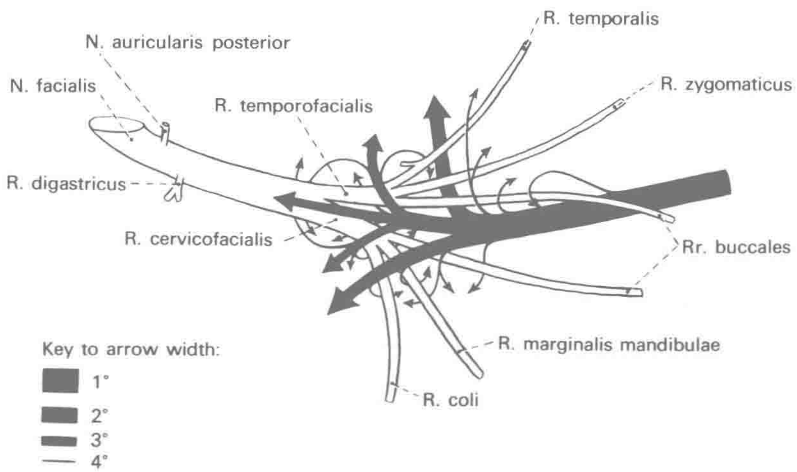

Fig. 1.3. General pattern of development of parotid gland. The black arrows indicate the direction of growth of the primordium of the parotid gland around the facial nerve and its branches. The width of the black arrows indicates the sequence of development. (Gasser 1970)

deep parts of the gland through several gaps in the facial nerve plexus. He concluded that the gland interdigitates with the nerve in an inconstant manner. Not to be outdone in the field of similes, he described the relationship of the gland to the nerve as that of 'a creeper weaving itself into the meshes of a trellis-work fence'. Having demonstrated that the gland was not

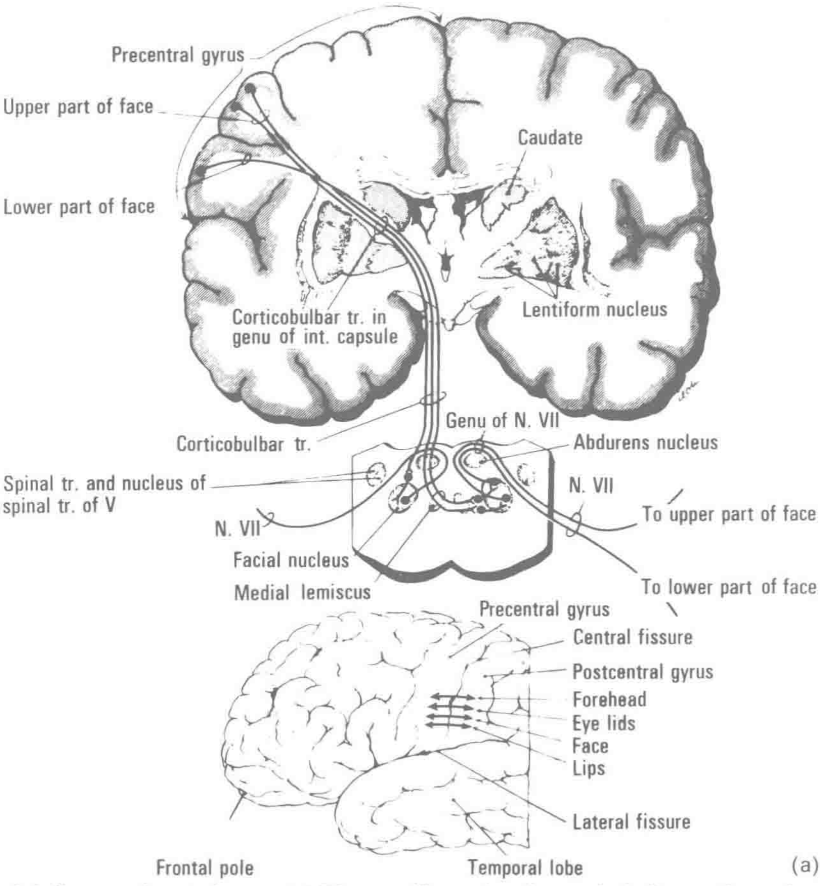

Fig. 1.4. Supranuclear pathways: (a) Diagram illustrating the corticobulbar pathway from the motor 'face' area of the cerebral cortex to the facial nucleus. The projection (largely by way of intercalate neurones) is bilateral to the lower part of the facial nucleus, which innervates the muscle of the upper part of the face. The projection is unilateral (contralateral) to the upper part of the facial nucleus, which innervates the muscles of the lower part of the face.

The diagram of the lateral wall of the hemisphere (which is in the lower part of the figure) shows the motor areas in the precentral gyrus and sensory areas in the postcentral gyrus associated with the different parts of the face. (Crosby and De Jonge 1963) composed of two lobes, McKenzie suggested that the terms 'superficial and deep portions' of the parotid were more appropriate. These terms have now been accepted by *Nomina Anatomica* (1966). If McKenzie is correct, parotidectomy with preservation of the facial nerve becomes a more difficult surgical problem.

If knowledge of the embryological development of the parotid gland were complete, it would be of great help in understanding the relationship between gland and nerve in the adult. It has long been known that the gland develops as an outgrowth from the buccal cavity near the future angle of the mouth and travels backwards towards the ear as an elongated solid cord of cells. As it approaches the facial nerve, the cord of cells divides and branches repeatedly. The cells at the extremities of the branches differentiate and proliferate to form the acinar cells and the solid cords become hollowed out to form the duct system. More recently, Gasser (1970) has studied in great detail the early development of the parotid gland around the facial nerve in human embryos. He reported that a complete cleavage plane through the gland primordium with a single mass of ductules (single isthmus) was never observed. The main branches, or ducts, generally passed superficial to the

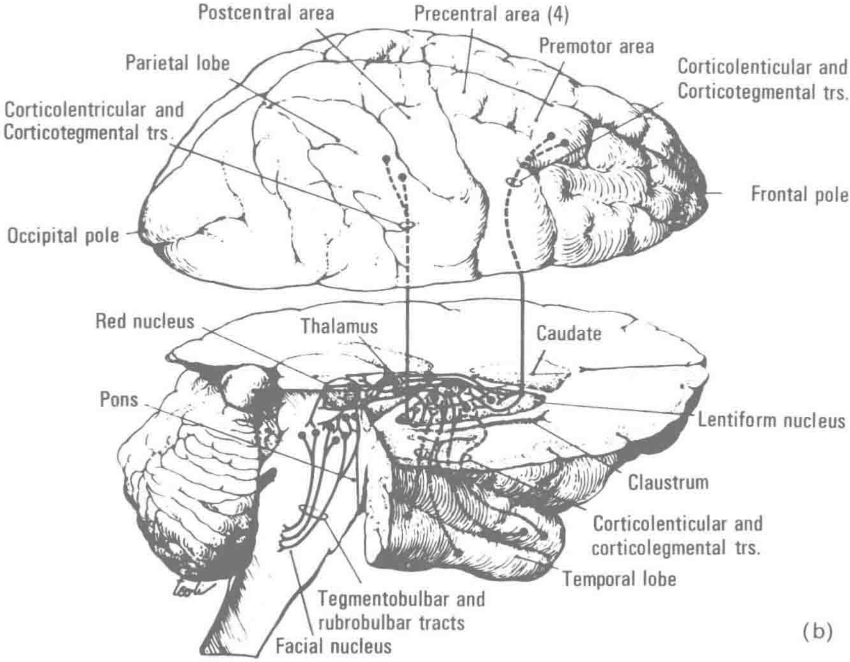

Fig. 1.4. (b) Diagram to illustrate some multisynaptic pathways from certain additional motor areas (premotor parietal and temporal) of the cerebral cortex to the facial nucleus. (Crosby and De Jonge 1963)

facial nerve and its cervicofacial division, but deep to the temporofacial division. Further subdivision of the gland ducts took place between the terminal branches of the facial nerve with which they intertwined (Fig. 1.3). Gasser's embryological studies reinforce the work of McKenzie and provide strong support for the traditional anatomical teaching, and they seriously undermine the position of Bailey and his supporters.

Upper motor neurones

The primary motor cortex for the face is in front of the central fissure in the precentral gyrus (Fig. 1.4). The size of the area of motor cortex representing the different members of the body is in direct proportion to the skills of movement employed by them, rather than to their muscle bulk. The face area of the motor cortex is therefore relatively large. Fibres from these cortical cells pass without synapse in the corticobulbar tracts to the motor nucleus in the pons. The majority of these fibres descend and cross the midline to synapse in the contralateral motor nucleus. Some descend without crossing to innervate the subnuclei responsible for the periorbital and frontalis muscles. These subnuclei thus have an ipsilateral and a contralateral cortical innervation, while the subnuclei for the lower half of the face receive contralateral corticobulbar fibres only.

In addition to the motor cortex for voluntary movement in the precentral gyrus, there are several other cortical areas concerned with the regulation of emotional and associated movements of the face. A number of these additional motor areas have been positively identified in man, e.g. in the preoccipital cortex, in the premotor cortex, and in the cingulate area, but documentation is not complete in man (Crosby and De Jonge 1963).

Unlike the direct corticonuclear tracts from the precentral gyrus, the pathways from these additional cortical motor areas to the facial nucleus contain numerous synapses. Some of these synaptic junctions are located in the hypothalamus, basal ganglia, and midbrain tegmentum. Emotional movements such as smiling at an amusing story, and automatic associated movements, e.g. unconsciously pursing the lips while concentrating on a problem, may thus persist in patients with a supranuclear facial palsy involving the direct corticobulbar pathway.

Hausman (1971) believes that irritation of the pyramidal (direct corticofacial) fibres produces convulsive twitching movements of the lower face on the opposite side, while involvement of the extrapyramidal (multisynaptic indirect) fibres to the facial nucleus results in a fixed facies, as in Parkinson's disease. However, the functional distinction between the pyramidal and the extrapyramidal systems is becoming blurred, and concepts based on them are gradually being abandoned, together with the terms pyramidal and extrapyramidal.