Neurology. — *"On Recovery of Function of the Facial Muscles after Hypoglossus-facialisanastomosis."* By Prof. E. D. WIERSMA.

(Communicated at the meeting of April 24, 1926).

A boy of 4 years was run over by a motorcar in August 1924. It is not quite sure whether he lost consciousness. An hour after the accident he vomited repeatedly. Directly after the trauma complete paralysis of the right n. facialis was established. The right corner of the mouth did not move when the boy was crying and the right eye could not be shut. The doctor who saw him an hour later stated deafness of the right ear. No further anomalies were found. The other cranial nerves and the extremities functioned normally. When in November 1924 the facialis-paralysis had not taken a turn for the better the patient was admitted to the neurological clinic of Groningen. There the verdict was given : complete deafness of the right ear and complete facialis-paralysis with reaction of degeneration on the right. For the rest there were no anomalies. After consultation with the surgeon a nerve-plastic was decided on. For the facialis-anastomosis only two nerves can receive consideration, viz. the hypoglossus and the accessorius. Although our considerations for choosing the hypoglossus are more appropriate to a surgical and neurological exposition, it is perhaps well to point out that, according to the experience of F. KÖNIG, E. LEXER and L. WREDE [1]) the hypoglossus-anastomosis is preferable to the accessorius-anastomosis, as well with regard to the secondary paralyses, as to the associated movements. My object in writing this article is to give an insight into the way in which the recovery of function of the paralyzed right half of the face was effected after the plastic. The hypoglossus was cut through, and the central end was attached to the peripheral end of the facialis, which also had been cut through. Before the cutting it had been ascertained that the exposed nerve did not respond anymore to electric stimuli. This operation was performed in the latter part of November. Of course it occasioned a complete paralysis of the right half of the tongue, which was soon followed by atrophy and reaction of degeneration.

This status persisted some time. The facialis muscles remained unchanged. Not before May 1925 did some spontaneous twitches of the right eyelids appear, which on closer examination had to be considered as associated movements. Whenever the tongue was moved while the boy was speaking or eating, contractions were perceivable of the right half of the face. At first they were still faint, but gradually they increased in

[1]) BIER, BRAUN, KÜMMELL, Chirurgische Operationslehre, 1917. p. 456—459.

intensity and extent, while after some weeks the whole right half of the face was moving continually, when the boy ate or spoke. These associated movements were so strong that at times we doubted whether the operation had yielded any profit.

Other concomitant movements revealed themselves about the same time. Whenever the left eye was shut, the right eye was also closed; when the boy was laughing or weeping the right corner of the mouth moved together with the left one. These associated movements were hardly visible at first, but grew stronger every week. In this way a simultaneous cooperation of the two halves of the face was brought about.

Little by little the associated movements were further modified, for in January 1926 it became clear that when the patient was speaking or eating i.e. together with the movements of the tongue, the associated movements of the facial muscles were much weaker. The tongue could be put out without large contractions of the facial muscles making their appearance on the right side, and at length hardly any contractions were visible. In addition weak, voluntary movements could be made with the right corner of the mouth. This condition persisted up to now (April 1926). These associated movements recur only when the child gets very excited: when he gets angry or also when he is merry.

These three phenomena, i.e. the movements of the facial muscles on the right, accompanying the movements of the tongue, the recurrence of the simultaneous movement of either half of the face and the slow disappearance of the associated movements, accompanying the movements of the tongue (so that an increased dissociation of the movement of the tongue and the face is brought about as in normal cases) and the voluntary contraction of the right corner of the mouth, require further explanation.

Is is easy to see that after regeneration of the hypoglossus that is attached to the facialis, the facialis-muscles will contract at every impulse originating from the hypoglossus-centrum. This will also be the case with movement of the non-paralyzed half of the tongue, because the two halves of the tongue will always cooperate. The action of the one hypoglossus-centrum will of necessity activate the other.

It is not so easy to explain the recurrence of the simultaneous co-operation of the facial muscles on the left and on the right side. As a rule the two halves cooperate. There is a regular association between the motor impulses on the right and on the left. But in our case the impulses for the left half of the face cannot excite simultaneous movements for the right half, because the nerve that is to transmit those impulses to the right half, is paralyzed. If in spite of this there is really cooperation between the two halves it must be accomplished along other paths. To render this conceivable I point to the marked association that always exists between

movements of the tongue and those of the face. When the tongue is put out, the mouth-aperture is widened, the naso-labial folds are getting more conspicuous, sometimes the forehead is wrinkled, frequently the eyes are closed or opened wide. The converse association also exists. Contractions of the muscles of the face are accompanied by movements of the tongue. When the eyes are fast shut, when the forehead is extremely wrinkled, or when the mouth is forcibly widened, movements of the tongue can distinctly be observed in the open mouth. This is noticeable above all in children, and in grown-ups with a lively face-play. Our knowledge of these associated relations affords an explanation of the cooperation of the two halves of the face of our little patient. The motorial impulses, arising from the right facialis-centrum, and moving the left half of the face activate the right hypoglossus-centrum, by which, as stated above, also the activity of the left one is brought about. The impulses that arise here, will produce a contraction of the right facial muscles. This then explains that a bilateral cooperation of the muscles of the face occurs. This instance shows that under some conditions the neurologist can turn to account psychological ideas. If it were not known that anatomical connections exist between the hypoglossus-centra inter se, and between the facialis- and the hypoglossus-centra, the above psychological speculations would entitle us to say with certainty that they must exist and that an elaborate experimental procedure will most probably bring them to light.

The third phenomenon, viz. the slow disappearance of the associated movements of the facial muscles accompanying the movements of the tongue, and the voluntary contraction of the right half of the face, also requires further explanation. A dissociation occurs, the contractions of the face become more dissociated from the movement of the tongue. The impulses from the right hypoglossus-centrum are utilized for the muscles of the face.

Analogous phenomena occur in the recovery of function, which is observed in some physiological experiments.

KENNEDY attached the nerve that innervates the extensors in a dog's foreleg to the nerve supplying the flexors, and the reverse. After regeneration recovery of function was effected by some exercise. When after trepanation the extensor-centrum in the cortex was stimulated the leg was flexed, and the reverse. Here, then, a transformation of the function of the centra takes place, for the animal has learned by practice that an impulse towards the extensors is needed for flexion of the leg. This is quite in keeping with our case ; the child has learned to move the muscles of the face by a stimulus towards the tongue.

OSBORNE and KELVINGTON [1]) have repeated these experiments in a slightly different way. After severing one of the main cord of the left plexus brachialis in a dog they attached the central end to the distal end

[1]) W. A. OSBORNE and BASIL KELVINGTON. Journal of Physiology, 1908

of the corresponding severed cord of the right plexus with due precaution to render only regeneration of the attached cords possible. After regeneration the animal learned by practising to use his foreleg again. When after trepanation the right hemisphere was stimulated the muscles of the left leg, which were innervated by the intact cords of the left plexus and also a movement of those muscles of the right leg which were innervated by the transplanted cord of the left plexus, could be seen. This goes to show that those movements are induced in the right leg by a motorial impulse towards the left leg. The dog has gradually learned this from experience, by observing sensations of feeling and here also by eye-sensation, just as in our case exercise has brought about the transformation of the hypoglossus-centrum.

The results of these physiological experiments and those of hypoglossus-anastomosis are to a great degree indicative of the development of the voluntary movements of the child. The neonatus shows only spontaneous movements and reflex-movements, from which voluntary movements gradually develop. The child is aware of every muscle-sensation, and these experiences will vary with the difference in duration, intensity and extent of the movement. Of every sensitive impression some trace is left behind, which belongs to a definite impulse. By way of those sensations the child will learn to find through exertion the right impulse for a wished for movement.

The great influence of sensitive impressions upon movements appears first of all from the fact that embryologically the sensitive paths are sooner developed than the motor ones, and secondly from the excellent comparative anatomical research by ARIENS KAPPERS [1]), which proves that the location of the sensitive paths and nuclei is constant, whereas that of the motor ones is variable and determined by the corresponding sensitive paths. Furthermore we must assume that an association appears between the sensations of the contraction of cooperating muscles and those of symmetrical groups of muscles. This enables us to imitate at will the attitude of the arm or leg on the opposite side. In the same way when the muscles of the face are in function a contraction will arise of equal intensity on both sides.

Just as in the child the voluntary movements will originate from the spontaneous movements and the reflex-movements, the animals of the above physiological experiments will learn through exercise and apprehension to alter undesigned movements into intentional movements. Our little patient thus apprehends that for every movement of the face a definite impulse starting from the hypoglossus-centrum is required. By dint of exercise harmony is established in the movement of the two halves of the face.

There is still another similarity with the development of voluntary

[1]) ARIËNS KAPPERS. Folia Neurobiologica. Bnd. I.

movements. The training for new intentional movements is first accompanied by a number of superfluous associated movements, e. g. for cycling, writing etc. These associated movements are after some time inhibited by the concentration of the energy upon the voluntary movements. They are not annulled, however, since they will recur when the said concentration is abated in one way or other. This becomes evident from the awkardness in emotional conditions, such as fear or anger, or from atactic writing, and from the accompanying movements of lips and face of some demented patients. In the same way the associated movements of the muscles of the face are in our patients not annulled but only inhibited, for they will recur directly with full vigour when the boy gets excited or angry or merry.

Now, how do the sensations of feeling arise that direct the motor impulses and are on that account of great significance for the voluntary movements?

Signal data on this point have been afforded by the very minute histological investigation by J. BOEKE [1]). After SHERRINGTON had demonstrated already some years ago that severing of the motor-nerves of the eye-muscles resulted in degeneration of sensitive end-bodies in the tendons, BOEKE established that the trochlearis and the abducens possess also centripetal fibres. Severing of these nerves brought about a degeneration of the sensitive end-bodies in the muscles and in the tendons. In the loose connective tissue in and round about the muscle a few sensitive end-bodies could still be found, which do not degenerate after the nerves of the eye-muscles are cut through, and whose impulses are probably directed to the centrum along the trigeminus. A similar condition was found by BOEKE for the hypoglossus. Most likely that of the facialis, with which we have to do here, does not differ much from it. Furthermore it is known that also in the joints sensitive nerves are lodged, which are stimulated when active or passive movements take place, and that the skin round about a point is more or less strained during a movement by which also stimuli run to the centrum. We are, therefore, safe to assume that sensation of movement can originate in different ways, viz. along the motor nerves and the sensitive nerves of the muscle and along the sensitive nerves of skin and joints. Also visual impressions can promote an accurate cooperation of the muscles. So there is a complex of causes for tactile sensation which is hard to disentangle. Most probably there are associations between those sensitive sensations, so that the one can compensate the other.

Little is known of each of these sensations. It would seem to me, that the clinic is competent to throw more light upon it. Sensation of movement can be established e.g. by moving the extremities in the joints passively and by recording the slighted movement observable. Another method

[1]) J. BOEKE. Studien zur Nervenregeneration. Verhandelingen der Kon. Akad. v. Wetensch. Deel XIX, N°. 5.

might be employed which has been suggested by CURSCHMANN [1]). First the threshold value of the cathodal closure contraction is determined in m.A: and subsequently the threshold value at which the contraction is observed. These two values are under normal conditions nearly equal. In the same way the threshold value of the movement and of the sensation of it in the joints can be estimated.

A number of experiments on peripheral facialisparalysis showed me that the sensation of contraction appears a little later here than the minimal movement. It is probable, therefore, that the facialis conducts also centripetal paths.

However, the awareness of movement is also experienced along the trigeminus. This view is corroborated by a case in which the ganglion Gasseri was extirpated because of violent trigeminus neuralgia. This brought on complete insensibility of the right half of the face and of the right half of the tongue. On examining the muscular sense there appear to be considerable disturbances. On showing the teeth the right half of the face is moved less than the left half. It is evident that the harmony between the movement of the muscles of the face on the right and on the left is diminished. This is also borne out by the following experiment. When I ask patient to raise a little first the left corner of the mouth and then do the same with the right corner, the latter movement is much stronger. Are we perhaps to ascribe this to the fact that the same muscular sense is aroused on the left, only with a much stronger contraction ? On applying galvanic stimuli it also appeared that the muscular contraction was felt on the right only when it was much stronger than on the left. Likewise on the right only a stronger electric contraction of the tongue is observed, whereas on the left a very weak, hardly perceptible movement is already apprehended.

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[1]) CURSCHMANN. Neurol. Centralblatt, 1915.