

*Experiments on the Restoration of Paralysed Muscles by means of Nerve Anastomosis.\**

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(Abstract.)

Restoration of voluntary co-ordinated movements after "nerve crossing," first demonstrated by Flourens, has since been from time to time the subject of investigation. The conclusions of Flourens have been confirmed by Rawa, Stefani, Howell and Huber, Langley, and myself. A practical application in surgery was first suggested by Létiévant, and within the past 12 years considerable development has taken place in this direction.

During the past two years I have performed about 30 experiments on monkeys and dogs in order to investigate several points from the physiological standpoint. These experiments fall naturally into three groups. The first deals with the methods of cross union or anastomosis between the peripheral segment of a divided facial nerve and a suitable motor nerve in the neighbourhood. The second series of experiments deals with anastomosis in the fore limb of dogs, in order to investigate some aspects of the question not overtaken by previous work on this part of the subject. The third series deals with the brachial plexus, its functions, and the methods of anastomosis applied to it.

The present communication is confined to an account of experiments with the facial nerve, of which there have been 10 performed. Of these 10, 6 were primary anastomosis and 4 secondary anastomosis, that is to say, in 6 the facial was cut, and its peripheral segment immediately anastomosed with the central segment of the substitute nerve, while in 4 the facial was cut, and left unattached for a period, precautions to prevent spontaneous reunion being taken, and then at the end of that period re-exposed, and united to the substitute nerve.

*Primary Anastomosis.*

In the primary anastomoses, two were in monkeys and four in dogs. Of the two monkeys, in one the facial was cut and attached to the side of the spinal accessory, and in the other it was attached to the side of the hypoglossal nerve. Voluntary dissociated movements of the face commenced

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to return in the former in 58 days, and in the latter in 42 days, and each of the animals had complete voluntary closure of the eye at about 100 days.

Of the four dogs, in two the spinal accessory was the substitute nerve, and in two the hypoglossal. Of the two spino-facial anastomoses, one was an end to side, and one an end to end, and the same variation was practised with the two hypoglosso-facial anastomoses.

The two spino-facial anastomoses commenced to recover voluntary dissociated movements of the face at 105 (end to side) and 90 (end to end) days respectively, and were almost complete as regards power to close the eye at 116 and 123 days respectively.

The two hypoglosso-facial anastomoses commenced to recover power to close the eye at 55 (end to side) and 84 (end to end) days respectively, and were very complete as regards closure of the eye at 142 and 107 days respectively.

Association movements of the face, on the normal distribution of the substitute nerve being innervated by the animal, were observed only in two of the experiments, one a spino-facial (end to side) in a monkey, and one a hypoglosso-facial (end to side) in a dog. In the latter case, every rapid movement of the tongue as in eating, licking lips, &c., was accompanied by a wink.

#### *Secondary Anastomosis.*

The secondary anastomosis experiments were performed in one monkey and three dogs. The monkey had spino-facial anastomosis (end to end) performed one month after section of the facial, and commenced to recover power to close the eye by means of the orbicularis at 46 days, and there was good reflex closure of the eye at 65 days.

In the three dogs the facial nerve was cut close to the stylo-mastoid foramen and precautions taken to prevent reunion, and anastomosis performed after the lapse of one month in two of the dogs, and after 100 days in the remaining dog. Of the two in which the interval of one month had elapsed, in one, a spino-facial (end to end) anastomosis, no recovery of voluntary function had taken place at 69 days, when the animal died. In the other in which a month's interval had elapsed, a hypoglosso-facial (end to end) anastomosis, voluntary dissociated closure of the eye commenced to return at 60 days and was complete at 93 days.

In the dog in which 100 days elapsed before substitution, an end to end spino-facial anastomosis was performed, and voluntary closure of the eye commenced to return at 124 and was complete by 167 days.

In every case except two, a physiological examination was made, and

proved that the recovery of movements which had taken place in the face was wholly due to impulses reaching the face *via* the substitute nerve. In both cases in which the examination was not made before death the animals died unexpectedly. In one of these no voluntary function had returned (dog), and in the other, in which restoration had taken place (monkey), the *post-mortem* examination showed that there had been no reunion with the central end of the facial, as the stylo-mastoid foramen was found completely obliterated by a bone plug which had been hammered into it at the operation.

As an Addendum, reports of two cases of spino-facial anastomosis are given. The first is a report twelve years after the operation, performed in a woman, and published in the 'Philosophical Transactions' in 1901, in order to show the ultimate result. The second is a report of a case of facial paralysis of three years' standing, in which spino-facial anastomosis was performed, and in which recovery commenced about three years after the operation.

The following general conclusions follow from the observations which are fully recorded in the paper:—

1. In any case of facial paralysis due to division or compression of the facial nerve, the best procedure, should spontaneous recovery fail, or be deemed impossible, is to attempt restoration of the damaged nerve.

2. Should efficient restoration of the nerve be impossible or be deemed impossible, anastomosis with the spinal accessory or hypoglossal holds out the most favourable prospects of recovery, given that the facial muscles are still recoverable from the point of view of duration of complete severance from the nutritive influence of the central nervous system.

3. Of the two substitutes, spinal accessory and hypoglossal, when the latter is used the restoration appears to commence sooner, but there does not seem to be a great difference in the ultimate result of the two substitutes, as far as the recovery of the face is concerned.

4. Of the new paralysis produced as a result of cutting the substitute nerve that which is produced when the spinal accessory is cut is much less objectionable than that produced when the hypoglossal is cut, and when the paralysis is to be left as a permanent defect, namely, when the peripheral segment of the substitute nerve is to be left unattached, the hypoglossal paralysis is not justifiable.

5. When, in consequence of the anastomosis, association movements are present in addition to voluntary co-ordinated and dissociated movements, these associated movements give no trouble and are not noticeable with ordinary movements when the spinal accessory has been used, but, if present,

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may be most objectionable and noticeable with ordinary movements when the hypoglossal has been used.

6. As regards the interval during which the paralysis has lasted before anastomosis has been performed, there appears to be no difference in the date of commencing recovery and ultimate result, whether anastomosis immediately follows section of the facial, or whether one month's interval at least is allowed to elapse before the anastomosis is performed after the facial has been cut.

7. The only way to make an efficient union between two nerves is completely to cut across all the nerve fibres in both nerves; methods such as Manasse's, designed to maintain the integrity of the nerve fibres, give inefficient unions.

8. In the course of recovery of independent voluntary co-ordinated movements, the orbicularis palpebrarum is first to exhibit recovery, and usually is the muscle which recovers best, and in no case has a perfect recovery in the movements of the face been proved to take place.

9. Reunion of the facial nerve is to be preferred to restoration by means of an anastomosis, as the latter involves interference with the distribution of another nerve, and association movements are sometimes troublesome.

10. The distribution of the facial nerve is, in dogs and monkeys, limited to its own side of the face, and recoveries cannot therefore be attributed to a supply from the opposite facial.

11. The distal segment of the divided facial, except for a short period immediately following division, on being irritated gives no response in the muscles, if no connections at a subsequent date have been made with the centres, either through its own central segment or by some other path, and, conversely, the occurrence of muscular responses on irritating the peripheral segment is proof that such connections have been established.

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