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ORIGINAL ARTICLE

FEASIBILITY OF USING DISTAL MOTOR BRANCHES TO INNERVATE THE INTRINSIC MUSCLES OF THE HAND (A CADAVERIC ANATOMICAL STUDY)

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ABSTRACT: The results of proximal nerve injuries with nerve gaps are less than perfect and provide only extrinsic muscle function with sensation at the best; intrinsic muscle function recovery is rarely seen. The imbalance in the hand resulting from denervation of the intrinsic muscles is usually treated by tendon transfers in a second sitting; since the results of tendon transfer depend on multiple factors, the final outcome may not be predictable for the individual patient the aims and objectives of this. Study to know the anatomical feasibility of the distal expendable motor branches of the median nerve to selectively reinnervate the intrinsic muscles of the hand. The method used are10 upper limbs from 5 cadavers were dissected in this study.4X loupe magnification was used for the dissection. Length and width of nerves were measured with measuring scale & calipers. **THE RESULTS:** The length of the thenar motor nerve is about 2-3cm, (which reaches upto distal wrist crease) and from there to distal end of the pronator quadratus nerve is 4.5-6.0cm.Pronator quadratus nerve can be lengthened by 1-1.2 cm by intramuscular dissection. The deep branch of ulnar nerve is 9.5-10.6cm length and can be easily brought to the distal end of pronator quadratus nerve The diameters of all three nerve matches in 90 -95% of the cases. This study has determined the cadaveric findings for the three nerves The Pronator quadratus width the length can be increased by intramuscular dissection helps in decreasing the nerve gap between the donor nerve and motor end plate. This cadevaric study concludes that Pronator quadratus branch of Anterior interosseous nerve can be transferred directly to the deep motor branch of Ulnar nerve. Nerve transfers should be an option prior to thinking of tendon transfers in the clinical situation.

INTRODUCTION: The results of proximal nerve injuries with nerve gaps are less than perfect and provide only extrinsic muscle function with sensation at the best; intrinsic muscle function recovery is rarely seen. The imbalance in the hand resulting from denervation of the intrinsic muscles is usually treated by tendon transfers in a second sitting; since the results of tendon transfer depend on multiple factors, the final outcome may not be predictable for the individual patient.

Nerve transfers with expendable motor nerves are more physiological and have already been applied for brachial plexus injuries. Recent literature has showed a renewed interest in utilizing nerve transfers at a more distal location for innervating the more distal musculature.

This cadaveric study on 10 cadaveric upper limbs seeks to determine the length and width of the deep motor branch of Ulnar nerve, the thenar motor branch of median nerve and the distal branch of Anterior interosseous nerve to the Pronator quadratus.

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In High Ulnar nerve injuries and low Median nerve injuries below the origin of Anterior interosseous nerve in the proximal forearm, opposition of the thumb and important intrinsic functions of the fingers are usually lost.

The search for better outcomes led us to study the feasibility of transfer of anterior interosseous nerve, which contains pure motor fibres and can be transferred either to the motor branches of ulnar or thenar motor branch of median nerve as the case maybe to innervate the intrinsic muscles of the hand. This study would help in extrapolating the finding to the clinical situation and help in standardizing distal pure motor nerve transfers without nerve grafts for severe proximal nerve injuries.

REVIEW OF LITERATURE: Direct surgical repair of the transected nerve is the treatment of choice in patients requiring restoration of nerve continuity. Patients with nerve defects are considered for a nerve graft procedure; the results of long nerve grafts are frequently not optimal and this leads to the search for alternative techniques for the reconstruction of long nerve gaps and/or proximal nerve injuries.

The use of nerve to nerve transfer is not a new concept. In 1948, Lurje[1] described the use of neighboring nerves for nerve transfers in the brachial plexus injuries when direct nerve repair was not possible. This early interest in nerve transfers was likely overshadowed by the popularization of nerve grafting technique by Millesi[2] and Narakas[3] in 1960 and 1970's; nerve transfers were largely forgotten thinking that nerve grafting was the only viable option.

Currently only a limited number of nerve transfers are routinely used and they are usually considered as salvage techniques in patients with avulsion injuries of brachial plexus; no wonder that applied in these less than optimal situations the results of nerve transfers have been variable.

Recovery of motor function depends on critical number of motor axons reaching the target muscle and re innervating muscle fibers within a critical time period; misdirected motor axons may not reach the target muscle. Proximal nerve injuries which are at a long distance from target muscle may not regenerate quickly enough and re innervation may not occur prior to irreversible muscle degeneration or fibrosis at the neuromuscular junction.

In many closed traction brachial plexus injuries, the nerves are in continuity and proximal healthy nerve roots are available; these types of injuries are usually treated with long nerve grafting procedures to anatomically reconstruct the nerve damage.

With proximal BPI, one of the alternatives to reconstruction of the brachial plexus is using the nerve transfers which is far superior; complication of downgrading the overall function by using donor nerves have not occurred. By transferring a more distal nerve to the injured nerve, the need for long nerve grafts is eliminated .Direct end to end coaptation of transferred nerve to recipient nerve is possible.

With a more distal nerve transfers, a shorter distance for re innervation of the target muscle is possible; this shorter gap distance between regenerating motor axons and the motor targets results in faster recovery than a more proximal nerve graft.

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High injuries to the Ulnar nerve results in functional motor loss of intrinsic muscle and recovery does not occur due to long distance from the site of injury to the muscle; when the Median nerve is intact a distal nerve transfer to the deep motor branch of ulnar nerve can be done by using the pronator quadratus branch of Anterior interossious nerve.

In low median nerve injuries distal to the origin of Anterior interossious nerve in the proximal forearm the opposition of thumb is usually lost. If there has been no functional recovery of the thenar muscle after nerve repair then transfer of the pronator quadratus nerve branch to the thenar motor branch is a possible alternative to or as a step prior to an opponent's plasty.

Wang and Zhu[4] were the first to study the transfer of pronator quadratus nerve to the thenar motor branch of the median nerve and deep branch of Ulnar nerves.

The main concept in these situations is to convert High nerve injuries to low nerve injuries by judicious use of nerve crossovers.

AIM & OBJECTIVES: To study the anatomical feasibility of the distal expendable motor branches of the median nerve to selectively re innervate the intrinsic muscles of the hand.

To look for an alternative way of restoring intrinsic muscle function by more physiological and less invasive way, reserving tendon transfer.

To know the length and width of anterior interosseous nerve at its termination as the Pronator quadratus muscle branch; the deep motor branch of ulnar nerve; the thenar motor branch of median nerve.

To see the proximity of Pronator quadratus branch to ulnar motor, thenar motor branch and whether they can be neurotised directly or not.

MATERIALS & METHODS: 10 upper limbs from 5 cadavers were dissected in this study.

4X loupe magnification were used for the dissection.

Length and width of nerves were measured with measuring scale & calipers.

The conduct of the cadaveric dissection was done thus:

Step 1: Exposure of the proximal median nerve.

Step 2: Exposure of the distal median nerve.

Step 3: Exposure of the distal ulnar nerve.

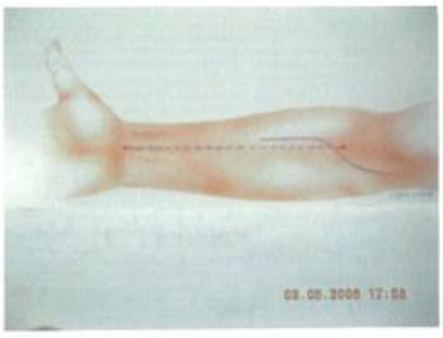

Figure 1

Figure 2

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An incision is made from the medial border of Biceps tendon and the inner margin of Pronator teres in the proximal forearm vertically down to the distal forearm between the palmaris longus and flexor carpi radial is tendon and this is further extended down to the mid palm.

The antebrachial fascia is incised, Iacertus fibrosis cut, median cubital vein ligated; the nerve is identified as it passes between the humeral and ulnar heads of the pronator teres; the superficial head is divided and retracted to expose the median nerve in the proximal forearm. The median nerve courses distally along the groove between the flexor digitorum profundus and flexor pollicis Iongus on the interosseous membrane.

Ulnar nerve is exposed from the wrist at & uyons canal to proximal forearm up to the dorsal sensory branch of ulnar nerve.

Cadaveric Dissection photographs:

Figure 3: Exposure of Proximal medium nerve

Anterior interroseous nerve takes origin from posterior aspect of main trunk of median nerve just proximal to the origin of pronator teres branch. The median nerve courses distally along the groove between the flexor digitorum profundus and flexor pollicislongus on the interosseous membrane and gives branches to FDP of index and middle finger.

Figure 4

Anterior interosseuos nerve is traced distally to pronator quadratus muscle.

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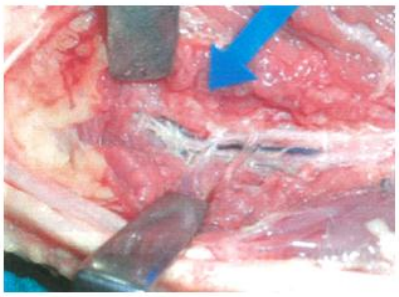

Figure 5: Exposure of distal Median nerve

Proquadratus branch enters the muscle underneath, courses intramuscularly upto 1-1.2cm and divides in to ulnar and radial branches.

Dissection of distal median nerve shows two main trunks which almost immediately divide into thenar motor branch, which is a short stout branch; it arises distally approximately at distal edge of the flexarrerinaculam it courses radically and then supplies thenar muscles. This branch can be dissected proximally upto 2.5 to 3.0cm which corresponds to the distal wrist crease.

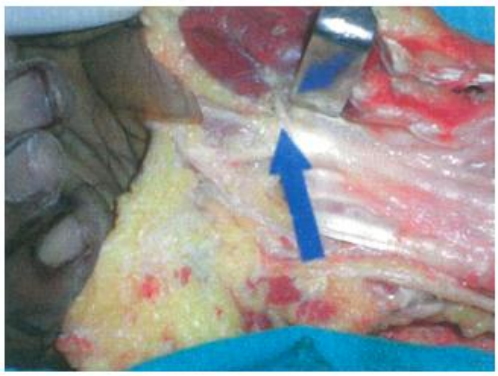

Figure 6

Figure 7: Distal ulnar nerve dissection

Deep motor branch Intraneural dissection from Guyons canal retrograde can be done up to dorsal branch origin, can be brought under deep tendons to distal end of Pr quadrates.

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Figure 8

End to end coaptation of ulnar motor branch to distal end of pronator.

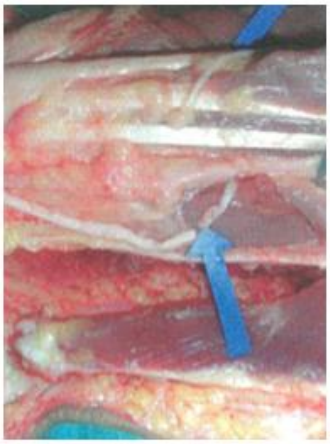

Figure 9

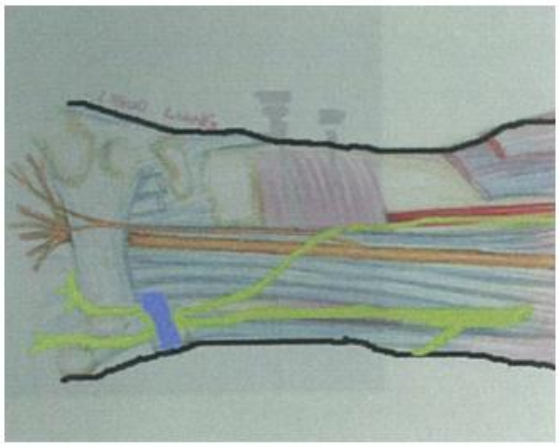

Figure 10

Retrograde dissection of thenar motor branch up to distal wrist crease, pronator quadratus with its distal most part making gap in between both the nerves 5-6cm.

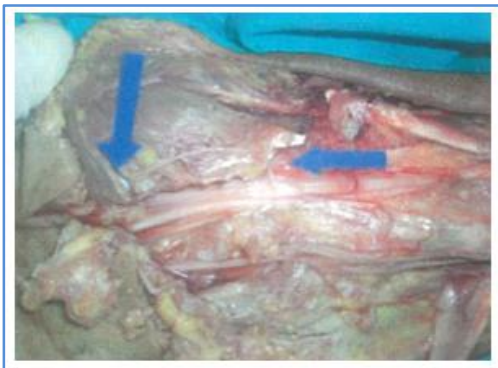

Figure 11

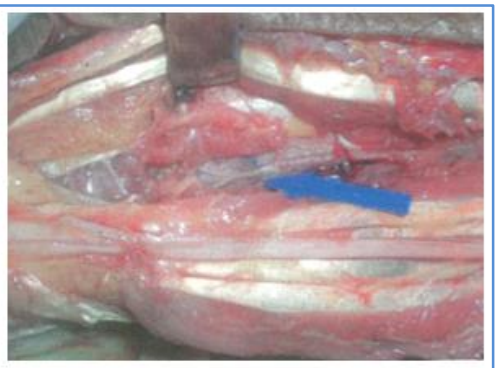

Figure 12

This nerve gap has to be bridged by nerve grafts.

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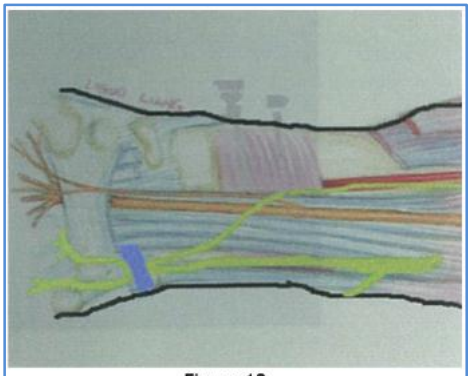

Figure 13

RESULTS:

Pronator quadratus N.			Ulnar motor nerve		Thenar motor branch	
Sl No.	**Length**	**width**	**Length**	**width**	**Length**	**width**
1	90mm	1.2mm	95mm	1.8mm	20mm	1.2mm
2	96mm	1.1mm	97mm	2.0mm	25mm	1.1mm
3	98mm	0.9mm	100mm	2.3mm	30mm	1.0mm
4	100mm	0.8mm	100mm	2.2mm	30mm	1.1mm
5	95mm	1.0mm	98mm	1.9mm	25mm	1.2mm
6	98mm	1.2mm	100mm	2.0mm	30mm	1.3mm
7	98mm	1.5mm	106mm	2.5mm	23mm	1.1mm
8	94mm	1.3mm	104mm	2.6mm	26mm	1.2mm
9	95mm	1.2mm	100mm	2.4mm	30mm	1.2mm
10	94mm	1.1mm	96mm	2.3mm	27mm	1.1mm

Table 1

The length of thenar motor nerve is about 2-3cm, (which reaches upto distal wrist crease) and from there to distal end of the pronator quadratus nerve is 4.5-6.0cm.

Pronator quadratus nerve can be lengthened by 1-1.2 cm by intramuscular dissection

The deep branch of ulnar nerve is 9.5-10.6cm length and can be easily brought to the distal end of pronator quadratus nerve.

The diameters of all three nerve matches in 90 -95% of the cases.

Pronator quadratus width 0.8-1.5mm.

Ulnar motor branch width 1.8-2.6mm.

Thenar motor branch 1.0-1.3mm.

Nerves length	Before dissection (cm)	After dissection (cm)
Length of pronator quadratus (in cm)	9-10	10-11.2
Ulnar motor branch retrograde intra neural dissection	Bifurcated at guyans canal	9.5-10.6

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Thenar motor branch retrograde intra neural dissection	At distal margin of flexor retinaculam	2-3

Table 2

DISCUSSION: Neurotisation or nerve transfer in brachial plexus injury is well established. Studies also exist from Mackinnon & Novak and the Chinese literature regarding the peripheral nerve transfers.

One of the prerequisites for the neurotisation is that the function gained has to be greater than the function lost. The function loss will be minimal after expenditure of pronator quadratus, as pronator teres and secondary pronators can compensate.

This study has determined the cadaveric findings for the three nerves

The Pronator quadratus width on average 0.8-1.5mm and the length can be increased by intramuscular dissection about 1.0-1.2cm. It helps in decreasing the nerve gap between the donor nerve and motor end plate.

The Ulnar nerve is about 1.8-2.6 mm width and length is 9.5-10.6 cm it can be easily separated from sensory branches as there is no plexus formation in between. It can be easily brought underneath the deep tendons to the distal end of the pronator quadratus nerve so that nerve ends can be coapted with-out the need for interposition nerve grafts; the mean width of the donor and recipient nerves are similar.

The Thenar motor branch width (1.0-1.3mm),length after retrograde dissection is 2-3cm approximately it coming up to the distal wrist crease; so the gap between the distal end of the Pronator quadratus to the proximal end of the Thenar motor branch of the median nerve is 4.5-6.0cm.The average width of donor and the recipient nerve are matcheble, but direct coaptation is not possible and there is a need for interposition nerve grafts.

CONCLUSION: This cadevaric study concludes that Pronator quadratus branch of Anterior interosseous nerve can be transferred directly to the deep motor branch of Ulnar nerve.

Neurotisation of the Thenar motor branch of median nerve by the Pronator quadratus branch requires interposition nerve grafts.

Nerve transfers should be an option prior to thinking of tendon transfers in the clinical situation.

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