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Principles of Tendon Transfer and Neurotization in Radial Nerve Palsy: Review Article

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ABSTRACT
Treatment for radial nerve palsy includes a palliative tendon transfer. Direct suture or nerve grafting as a means of nerve healing are not practical or reasonable, and it can be considered only in the early stages. Functional restoration being nerve deficient alone is a strong indicator that a nerve transplant would be successful. Region is the goal rather than morphological reconstitution of the destroyed nerve (s). The aim of the current review is to summarize the principals of tendon transfer and neurotisation in radial nerve palsy.
Keywords: Tendon Transfer, Radial Nerve Palsy, Motor recovery, Review, Zagazig University.

INTRODUCTION

Peripheral nerve damage that cannot be repaired is the most frequent reason for upper extremity tendon transfer surgeries. This covers nerve injury that cannot be physically treated, such as root avulsions, as well as damage to the nerve that is not improved by attempts at nerve transfers, direct nerve repair, and nerve grafting may all be used. Moreover, tendon transfer techniques are frequently suggested when motor end-plate fibrosis makes it impossible to do muscle reinnervation due to peripheral nerve injuries that manifest so late [(1)] .

Besides from cerebral palsy and spinal cord injuries, other common indications include tendon ruptures in rheumatoid arthritis patients and muscle or tendon loss as a result of trauma. Another two rare disorders that can lead to impairment and may benefit from tendon transfer surgery are leprosy and poliomyelitis [(2)].

It should be emphasised that in some cases, to enhance upper extremity function, other forms of therapy may be utilised instead of or in conjunction with tendon transfer treatments. They include non-operative techniques like static and dynamic bracing, as well as surgical procedures like tenodesis, nerve transfer, free functional muscle transfer, and tendon grafting are among examples. All possible tendon transfer candidates should have their roles in these other therapeutic options thoroughly assessed [(3)].

Ingrowth of nerve fibres into a region devoid of nerve fibres is also referred to as neurotization. A distal stump of a transected peripheral nerve is denervated after Wallerian degeneration. Following a neurorrhaphy, neurons feeding the original nerve re-neurotize the distal stump (nerve-to-nerve neurotization). If a different donor nerve is used, it is necessary to execute a neurotization by nerve transfer of axons from a different zone of neurons in order to supply the distal stump's end organs. The goal of the technique is to neurotize the denervated distal stump. The actual procedure is called neurorrhaphy, which is also known as nerve grafting [(4)].

The indications for particular nerve transplants are constantly changing as our understanding of donor nerves expands. In general, these issues are a result of an injured nerve's proximal segment being inadequate, other treatments being administered with insufficient time to fully restore the nerve, or operating in the wounded area being too risky. These injuries include root avulsion, High injury with long regeneration distance, time from injury extended past the point at which grafts are acceptable, segmental nerve injury requiring multiple grafts, segmental nerve injury without available grafts, scarred area of injury containing vital structures with unacceptable risk of operative injury, and undefined level injuries such as radiation trauma are some examples of injuries that cannot be classified [(5)].

Contraindications typically refer to circumstances when different forms of care are anticipated to yield superior outcomes or results that are equal but involve less morbidity. Reconstruction is not necessary for degree 1 or 2 traction injuries that will fully recover. As the majority will recover on their own, for the same reason that early surgery should be avoided, neuritis should be identified. When a pregnant woman sustains a brachial plexus injury that needs to be rebuilt, the best therapies are primary repair or nerve grafting [(4)].

Trustworthy tendon transfers, such as opponensplasties and radial nerve tendon transfers, have historically provided equally or more appealing results when the recipient muscle has experienced irreversible denervation atrophy or when no viable donor nerves are available. Finally, if possible, grafts should be used to treat adult injuries that are close to the final destination [(4)].

The aim of the current review is to summarize the principals of tendon transfer and neurotisation in radial nerve palsy.

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Principles of Tendon Transfer Procedures

Table (1): Principle Criteria for Tendon Transfer [6].

1) Supple joints prior to transfer,	2) Soft tissue equilibrium,
3) Donor of adequate excursion,	4) Donor of adequate strength,
5) Expendable donor,	6) Straight line of pull,
7) Synergy	8) Single function per transfer.

Biomechanics

The capacity of a transplanted tendon to move a joint is influenced by a variety of biomechanical parameters. Yet, four key ideas stand out as being very significant: the moment arm, the MTU excursion, the MTU force-generating capacity, and the transfer's established tension. As was mentioned above, adequate MTU excursion is crucial, and excursion can be increased by using the tenodesis effect [7].

Force-generating Ability

The muscular belly's physiologic cross-sectional area (PCSA) directly correlates with the amount of force that an MTU can produce. For instance, the brachioradialis can generate roughly twice as much force as the FCR. The brachioradialis' larger PCSA accounts for the majority of this difference. Other structural factors, though to a lesser extent, also influence a muscle's capacity to generate force [8].

For instance, the amount of force that can be produced depends on the pennation angle, which is the muscle fibres' position in relation to the MTU's long axis Compared to muscle fibres that are aligned almost parallel Obliquely positioned muscle fibres are less effective in producing force along the long axis of the MTU. For instance, the hand's interossei muscles, which are frequently weak, have a significant pennation angle [7].

The Moment Arm

The amount of movement and the force of a tendon transfer are both determined by the moment arm. The moment arm is then calculated using the distance between the tendon line of action and the joint axis of rotation. The moment arm diminishes as the tendon line of action gets closer to the axis of rotation of the joint [9].

When the joint axis of rotation and the tendon line of action are separated, the moment arm expands. A tendon that is positioned close to the joint and, as the joint moves, develops a little moment arm, improving the arc of motion at the expense of strength. As the joint moves, a tendon insertion farther from the joint will have a larger moment arm, producing a stronger movement but with a more constrained arc of motion [6].

The arrangement of the joint and tendon, as well as how the joints move, cause the moment arm to change is adjusted. It is necessary to strike a balance between the demands for movement strength and range of motion while selecting the right moment arm [2].

Tension of the Transfer

One of the crucial elements of the procedure is the passive tension level at which the tendon transfer mechanism is developed. To produce the highest force, the muscle needs to be properly tensioned. The degree of actin-myosin overlap varies with muscle length truly determines the optimal tension [10].

However, the maximum actin-myosin overlap cannot be felt by the surgeon because it differs from the highest passive tension. Before to surgery, the MTU should be adjusted at a tension that is as close as is practical to its resting tension. To find the appropriate tension to set the transfer at, this determination was made [3].

Yet, it is undoubtedly better to fix a tendon transfer too firmly than too loosely. tends to extend at the tendon transfer junction and relax after surgery, thus a transfer that is established with insufficient tension won't become better over time [2].

Principles of Nerve Transfer

The fundamentals of nerve transfer encompass both technical and patient-related considerations. The surgical technique and necessary anaesthesia should be tolerated by the patient, together with stability, a suitable amount of soft tissue covering, and infection-free wound bed. Moreover, the recipient motor neurons' controlled joints need to be flexible. With regard to the affected nerves, the surgical method should be as nontraumatic as possible, and obstructive scar tissue should be eliminated.

Due to the great distance between the lesion and the target organ, peripheral nerve lesions at or near the elbow cause denervation, a loss of feeling, and may not recover. Even with prompt diagnosis and treatment, the axon regeneration process is not always able to reach the targeted muscle before irreversible changes have been made. Promote re-innervation close to a specific target organ is the main goal of nerve transfers following proximal nerve loss (whether a muscle or skin) [1].

Axonal regeneration advances between 1 and 2 mm every day. During 12 to 18 months of denervation, muscle fibres experience irreversible alterations, therefore immediate therapy is essential for regaining functionality. Even when treated within three months of the initial injury, very close lesions in the arm or brachial plexus have a high risk of causing irreversible muscle atrophy before the regenerated axons reach the motor end plates [9].

When a motor neuron is close by, the distance for axon regeneration is shortened, which reduces the time for muscle re-innervation to the motor end plate is transferred. In this way, nerve transfer encourages functional repair as opposed to anatomical reconstruction. The fundamental idea behind nerve transfer surgery is this [8].

Without the use of nerve grafts, tension-free sutures are placed between the donor and recipient nerves to ensure that the largest number of regenerating axons is directed towards the end organ is another crucial notion. Working away from the injured area allows the utilisation of a pristine, vascular field that won't obstruct nerve regeneration. Even while Even months after the lesion, sensory receptors have a longer recovery window; earlier repairs undoubtedly result in better outcomes [1].

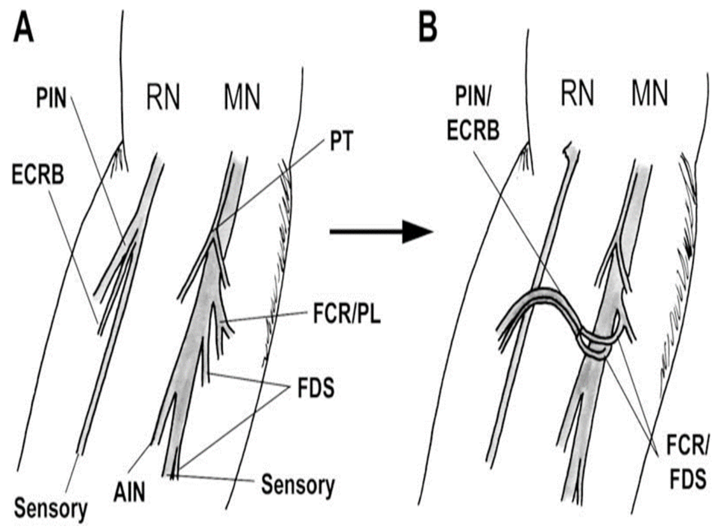

Figure (1): Radial nerve deficit. Transfer of the motor branch to flexor digitorumsuperficialis muscle to the extensor carpi radialisbrevis, and the motor branches to flexor carpi radialis muscle and palmarislongus muscle, to the **PIN**. **PIN**: Posterior interosseous nerve, **ECRB**: Extensor carpi radialisbrevis, **FCR**: Flexor carpi radialis, **FDS**: Flexor digitorumsuperficialis, **PL**: Palmaris longus [11].

The intraneural architecture has become better understood, and functional re-innervation has come to be prioritised over morphological repair in nerve transfer surgery over the past 20 years. As a result, treating the damage in terms of functional recovery is preferable to treating it in terms of pure anatomic repair in some situations with high-level nerve injuries [9].

Because a nerve transplant does not need obtaining tissue from a distant location, as well as because nerve transfer has been shown to have results that are equivalent to or better than lengthy nerve grafts, having a nerve deficiency alone is a good sign that nerve transplant will work [7].

Typically, functional restoration being nerve deficient alone is a strong indicator that a nerve transplant would be successful. Region is the goal rather than morphological reconstitution of the destroyed nerve(s). Without having to divert other tendons or muscles, which can sap some of their initial strength, a particular movement can still be done by the original muscle [3].

Table (2): Principle Criteria for Donor Nerves Transfer [12].

Principles of motor nerve transfers	Principles of sensory nerve transfers
1. Donor nerve near target motor end-plates.	1. Donor nerve near target sensory receptors.
2. Expendable donor nerve.	2. Expendable less critical donor nerve.
3. Pure motor donor nerve.	3. Pure sensory donor nerve.
4. Donor-recipient size match.	4. Donor-recipient size match.
5. Donor function synergy with recipient function.	5. Side-to-end (terminolateral) repair if necessary; end-to-end repair is preferable.
6. Motor reeducation will improve function.	6. Sensory reeducation will improve function.

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