Decision-Making in Cases of Radial Nerve Palsy and Pathology

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INTRODUCTION

Traumatic peripheral nerve pathology is a complex situation and involves a possible spectrum of injuries to the affected nerve, ranging from a transient conduction block to the entire section of the nerve. According to Shao et al.[1], the radial nerve is affected in 11.8% of humerus fractures and it represents the nerve injury most frequently associated with long bone fracture.

Many times, the conservative management and follow-up of radial nerve injuries, as well as the correct timing and indication of surgical treatment with its range of reconstructive options, pose a dynamic, complex scenario for the treating physician. This counterpoint exposes two perspectives for the resolution of a common problem. In this case, different situations are exposed within the medical practice regarding the traumatic pathology of the radial nerve.

1. Radial nerve palsy after a closed humeral shaft fracture is a frequent condition in practice. What is your usual management in these cases?

Mariano Socolovsky (MS): Although it is the most frequent palsy (and associated anesthesia) after a long bone fracture, its incidence, according to the literature, does not exceed 12%.[1] Our line of treatment is generally conservative. The reported spontaneous recovery rate is high, ranging between 72% and 93%.[1,2] We consider the role of images (ultrasound and magnetic resonance neurography) to be essential in the diagnosis and treatment of these lesions, for they allow us to determine the continuity (or not) of the nerve, as well as the degree of injury. If we observe a break in the continuity of the radial nerve, entrapment, or some other injury, we disregard the initial conservative treatment and offer a surgical exploration of the nerve with eventual reconstruction, according to the intraoperative findings. Another exception would be when the treatment of the fracture itself warrants an open exploration, reduction, and osteosynthesis, a circumstance that should be used to inspect the nerve. Finally, I should clarify that, although our therapeutic proposal is generally conservative, in the event of surgical treatment of the fracture or the confirmation of neural section in imaging studies, we indicate the exploration of the nerve.

Sebastián Valbuena (SV): 70% of radial nerve palsies associated with a humeral fracture heal spontaneously, so observation is usually recommended.[1,3-6] However, there is evidence that early explorations lead to recovery rates of 89.8% compared to 68.1% in late explorations.[4]

Currently, most humerus fractures are surgically treated; therefore, my behavior regarding radial nerve palsy depends more on the characteristics of the fracture than on the neural injury.

In type A, B1, and B2 fractures, I prefer to explore the radial nerve evaluating the injury, avoiding bone entrapment and potential damage from closed manipulations, and use 4.5 mm locking DCP or LC-DCP systems. In high-energy, comminuted, multifragmentary fractures (B3 and C), neural reconstruction achieves poor outcomes.[7,8] Consequently, I use MIPO or intramedullary systems without exploring the radial nerve (except in open fractures), deferring the treatment of paralysis.

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In children with open fractures which will be surgically treated, I systematically explore the nerve. In elderly patients with osteoporotic fractures and an indication of conservative treatment, a radial nerve palsy does not change my behavior and I carry out a clinical control.

In cases of brachial plexus palsy and humeral fracture, I always explore the radial nerve and perform open reduction and internal fixation to rule out double injury.

2. In the case of opting for conservative management as the primary choice: how do you carry out the clinical follow-up of the patients and which do you consider as key points to assess their recovery?

MS: Clinical parameters, first, and neurophysiology, second, are the mainstays of follow-up at this stage. The sensitive evaluation may give us an initial presumption of recovery, although it does not guarantee an improvement in the paralysis. We must calculate the time it will take to observe movement in the paralyzed muscles from the point of the presumed nerve injury to the effector muscles, taking into account that the axon growth rate is around one millimeter per day and can accelerate up to 3 mm/day in children. Rehabilitation is essential in this period, provided that the treatment of the fracture allows it. The advantage of neurophysiology is that it allows us to observe motor recovery before it is detected in the physical examination, although this fact does not guarantee that recovery is complete or useful. In the context mentioned in the previous question, if there is an imaging study that does not show a serious nerve injury, but no clinical improvement is observed after the calculated times, we must abandon conservative management and offer a nerve exploration. In short, conservative behavior should not be regarded as passive behavior. Watchful waiting must be active.

SV: Fundamentally two pillars:

1) Dynamic splint, with the wrist in extension and free metacarpophalangeal joints, associated with passive joint mobility exercises.

2) Evaluation: partial alteration of sensation in the dorsal aspect of the first commissure, sweating, and muscular dysfunction (without atrophy) indicate neuropraxia. Lack of sensation, motor paralysis, and a positive Tinel sign suggest axonotmesis or neurotmesis, which are difficult to differentiate from each other. A progressing Tinel sign signals recovery.

Ultrasound can help assess nerve continuity, a neuroma, or neurotmesis.

The first muscles to regain function are the brachioradialis and the extensor carpi radialis longus, and the last is the extensor indicis; clinical follow-up is based on evaluating them. The expected recovery time can be estimated by measuring the distance between the fracture and the point of innervation of the brachioradialis, 2 cm above the epicondyle, calculating a velocity of 1 mm/day.

The average time to start recovery is 7.3 weeks.[1] Differences are observed between low-energy injuries (3.1 weeks) and high-energy injuries (12 weeks).[8] Complete recovery is usually observed after 6 to 12 months.[1,6]

3. What time do you consider appropriate to perform electromyography and what prognostic value do you assign to the result?

MS: Electromyography should never be performed before 21 days after nerve injury, the minimum time for the study to detect clear signs of denervation. I believe I have answered the second part of the question in the previous point.

SV: Electromyography with Nerve Conduction Velocity, in my experience, only provides medicolegal value. If requested, it should be done after 3 or 4 weeks, since that is the moment we can start to observe muscle fibrillation potentials, positive waves, and short-duration monophasic action potentials.[3,9]

Some authors propose its use to define surgical behavior when there are no changes between baseline electromyography and control electromyography after 6 weeks.[3]

Nerve conduction studies do not allow an early differentiation between a very injured nerve and one that has not yet recovered, nor does it predict the potential for a nerve to recover, it only anticipates clinical recovery for a few weeks;[7] therefore, I do not usually use it to make decisions. I only request electromyography for medicolegal reasons (workplace accidents, traffic accidents, etc.) at 4 weeks and 8 weeks later if there is no recovery.

4. What is the time that you consider the limit to maintain conservative treatment or what negative parameters do you consider relevant to suspend it?

MS: In line with what has already been mentioned, and aside from all the clinical, imaging, and neurophysiological conditions described above, I would say that 6 months from the time of injury is the limit after which conservative behavior should be abandoned.[10] This is clearly a general rule, the surgeon must evaluate each case in particular, because there will be occasions in which surgery must be indicated before that time or even later if there are at least incipient signs of recovery.

SV: There is no consensus in the literature on how long a conservative treatment should be sustained. Expectant management has traditionally been proposed between 3 and 6 months, followed by a delayed neural examination when there is no functional recovery.[3] However, it has also been reported that if there is indeed motor recovery, signs of it should be observed within 2 to 3 months.[11,12] I consider that, in patients with low-energy fractures, we should not wait more than 3 months to make a decision, either for a radial nerve exploration or for the definitive treatment of the paralysis. The absence of progression of a Tinel sign or the presence of neuropathic pain are negative parameters to be considered in the interruption of conservative treatment.

In patients with high-energy fractures where recovery is usually slower, I usually request an ultrasound to assess nerve continuity; if there are ultrasound signs of neural disruption or nerve entrapment, I plan a reconstruction. If the ultrasound does not show signs of harm, I maintain expectant management and I agree with the patient on the time limit for watchful waiting, which will not exceed 6 months.

5. What is the time limit for exploration and reconstruction with grafts in a lesion of the radial nerve at the level of the middle third of the arm? Is there a limit on the size of the defect?

MS: From 6 months after the onset of paralysis onwards, the results of an examination and eventual repair tend to decline rapidly, which is why it is recommended to do it before or at that time.[13] Regarding the maximum length of a graft repair, we have various publications on our casuistry of the positive outcomes obtained with long grafts, even more than 20 cm in length, specifically for nerve transfers in the brachial plexus. The problem with using long grafts does not lie in their extension, but in the extent of the primary damage that the nerve has suffered. In other words, if we need to place a 15 cm graft, for example, on a radial nerve, this implies equivalent damage to the affected nerve, a poor or null outcome, and therefore this cannot be similar to the aforementioned transfers with long grafts in the brachial plexus. To be concise after these considerations, I would say that if we must use grafts longer than 10 to 12 cm, we should consider abandoning the primary repair and consider other therapeutic alternatives, such as tendon or nerve transfers, which will have a more predictable positive outcome.

SV: I usually explore radial nerve palsies early, and if I detect a severe injury or section, I usually opt for reconstruction with a graft. Except for open wounds, the nerve usually suffers compression or elongation trauma that affects a variable intraneural sector, and the success of a nerve suture will be conditioned to its being performed without tension, from a healthy proximal and distal end; therefore, I usually use nerve grafts.

The outcomes with grafts are usually good and the extension of the wrist—and to a lesser extent, the fingers—is recovered, but it should be noted that poor outcomes have been reported in up to 40% of cases. Better outcomes are obtained in defects that require grafts of a length <4 cm and using grafts in defects greater than 10 cm is not recommended.[9,14]

In patients with late paralysis (after 3 months), I currently prefer to perform reconstruction of radial nerve function with nerve or tendon transfers.

Children are an exception, spontaneous recovery can be expected up to 6 months. Excellent results are achieved with nerve grafts, even with long grafts, probably due to the greater potential for neural regeneration and plasticity.[15]

6. What factors are critical when evaluating a radial nerve injury to consider a primary reconstruction with radial nerve grafts versus treatment with tendon transfers?

MS: The extent of the primary injury, the time elapsed since the trauma, the age of the patient, the location of the injury (distal or proximal, the more distal the better), among others, are all factors that impact primary reconstruction. The sum of these factors will determine the choice of a repair with grafts or a transfer, either nerve or tendon.

SV: There are mainly two, those inherent to the injury and those inherent to the patient.

In relation to the injury, the time elapsed and neural defect are the most important. Time is related to the minimum required for reinnervation and motor endplate degeneration, which is estimated to be irreversible between 12 and 18 months, and muscle degeneration between 18 and 24 months.[9] The recovery is not only determined by the size of the graft, but also by the environment where it will be placed, since an area with abundant fibrosis (open wounds or infections) is poorly vascularized, and is less favorable for the regeneration of the grafts. Radial nerve injuries associated with vascular injuries show less potential for recovery.

I only use grafts in early reconstructions, and I do not recommend them in an injury of more than 6 months. In late reconstructions, I prefer to use tendon or nerve transfers.

Comorbidities and the age of the patient are influencing factors. After the age of 50 and in smokers, the outcomes tend to be less predictable, and they are candidates for a tendon transfer.

7. What do you think would be the ideal situation to indicate nerve transfers in a patient with radial nerve palsy?

MS: I would indicate them to a relatively young patient (up to 50 years of age) in whom a repair with grafts cannot or could not be performed, who has no problems waiting months for a favorable outcome, and who prioritizes obtaining independent mobility in the extension of each finger as a final outcome. The patient also has to assume that if the outcome is not good, an eventual and subsequent tendon transfer could be partially affected.

SV: A young patient with a high-energy injury and local conditions portending a poor prognosis for nerve reconstruction, who did not recover after 4 months from injury, or in whom a lesion that requires grafting with a defect >4 cm is observed during radial nerve exploration.

8. What is the nerve transfer scheme used in your daily practice in upper and lower radial nerve palsies? Briefly justify your choice.

MS: In low lesions, a branch of the flexor digitorum superficialis to the extensor carpi brevis and a branch of the palmaris longus to the posterior interosseous nerve. In high lesions, I would add an ulnar donor to the axonal donors from the median, specifically branches of the ulnar anterior, as in Oberlin surgery but for the nerve of the long head of the triceps.[16] These techniques are the most proven and the safest (lower functional risk for the donor nerve).

SV: I prefer 'hybrid' transfers. I use tendon transfer from pronator teres to extensor carpi radialis brevis, because in my experience it gives faster and more predictable results.

In young, motivated, non-smoker patients, I have performed reinnervation of the posterior interosseous nerve, using flexor carpi radialis bundles, with outcomes not as good as those published. After 2017, Dr. Rui Ferreira (Recife, Brazil) taught me his technique, and I was able to evaluate its results in humanitarian missions. I prefer to transfer the terminal branch of the anterior interosseous nerve, which innervates the pronator quadratus, to the anterior branch of the posterior interosseous nerve that supplies the extensor digitorum communis, the extensor digiti minimi and the extensor carpi ulnaris, associated with a tendon transfer from the pronator teres to the extensor carpi radialis brevis and a "re-routing" of the palmaris longus to the extensor pollicis longus. This technique (not yet published) achieves a good extension of the fingers while preserving individuality, without losing power in the flexors of the wrist and fingers. In low paralysis, I explore the posterior interosseous nerve and, if possible, do the same nerve transfer and re-routing from the palmaris longus to the extensor pollicis longus.

9. What are the benefits, according to the literature and your daily practice, by which you would incline your choice to perform nerve transfers over tendon transfers?

MS: Nerve transfers have, in my opinion, two disadvantages: 1) although according to what has been published, their outcomes are good,[17,18] the series and the number of patients are scarce, and they tend to come from a not so large group of authors; and 2) the outcomes take from 8 to 12 months and require intensive rehabilitation. In contrast, tendon transfers for radial palsy are versatile and reliable procedures with positive results over decades of experience with countless reports and personal experiences, they are entirely reproducible and do not require special training in nerve microsurgery. One could say that independent mobility for individual extension of each finger is not as good with tendon transfers. Due to the above reasons, and although it sounds strange coming from a neurosurgeon dedicated to nerve surgery, I am currently inclined towards tendon transfers in radial palsy, both when a primary reconstruction has failed and due to the impossibility or delay in performing it. Of course, this choice could change in the future if nerve transfers, which have been described much more recently than tendon transfers, demonstrate reliability similar to that of the latter.

SV: I consider that nerve transfers are shown as a promising option, but there is still not enough evidence to show that their results are superior to those of the classic tendon transfers in radial nerve palsy.[19] In my opinion, their main advantage is that they achieve individuality in the extension of the fingers, something that is not obtained with tendon transfers, apart from the individuality in the extension obtained from the proximal interphalangeal and distal interphalangeal joints at the expense of the intrinsic muscles. In contrast, the recovery time is longer and there is a risk of incomplete recovery.[19] Bertelli compared nerve transfers with tendon transfers and observed similar results, clearly leaning in favor of nerve transfers since they achieved greater fist strength, without the tendency to lateral deviation or loss of some degrees of wrist flexion, and without compensatory hyperextension of the metacarpophalangeal joint of the thumb at extension.[20]

Tendon transfers are safe, have predictable outcomes, and allow faster recovery, with options adaptable to each patient and the possibility of revision, something difficult to do in a nerve transfer. Their limitation lies in the lack of individuality in the extension of the fingers, this justifies my leaning towards 'hybrid' procedures.

10. What is your first choice of technique for the management of a neuroma of the superficial sensory branch of the radial nerve? And, in the case of failure, what is the alternative contemplated for the resolution?

MS: The first choice is nerve reconstruction, preferably direct or with grafts. The great discomfort and functional disability generated by these types of lesions justify the morbidity caused by taking the graft, generally of the sural or external saphenous nerves, but if the nerve defect is <3 cm, tubes can be used as for digital neuromas. Reconstruction prevents or lessens the formation of a proximal neuroma, which is the source of discomfort. The nerve can then be sectioned more proximally from where it is injured, and placed deep into muscle or loose tissue. This variant is usually not as effective as the previous one. Another alternative to avoid the formation of a neuroma, originally described for neuromas in amputees, is Targeted Muscle Reinnervation,[21] which consists of joining the superficial radial nerve with some sacrificial motor branch. The treatment of a painful neuroma in any location is a problem that is difficult to solve, hence the large number of methods described to treat it and the lack of one that prevails over the rest.

SV: I perform the resection of the neuroma and the ligation of the nerve and its intramuscular transposition, without deep tension. Depending on the location, I delve into the brachioradialis or the pronator quadratus. In relapses, if the length of the nerve allows it, I carry out an intraosseous relocation in the radius. If the distance of the nerve does not allow it, I opt for a termino-lateral microsurgical suture on itself (nerve loop) and its more proximal deepening.

I have abandoned the attempts to reconstruct sensation with nerve grafts or neurotubes and wrapping techniques (vein wrap) in the radial nerve, since its superficiality does not allow the symptoms to completely disappear and the loss of sensation in its territory is well tolerated.

Conflict of interest: The authors declare they do not have any conflict of interest.

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