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Systematic Review of Tendon Transfer Versus Nerve Transfer for the Restoration of Wrist Extension in Isolated Traumatic Radial Nerve Palsy

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Abstract

Purpose: To compare the outcomes of tendon transfer and nerve transfer for radial nerve palsy.

Methods: We performed a systematic review of the literature in EMBASE, PubMed, and Cochrane Database to include studies that address persistent traumatic radial nerve palsy treated with tendon transfer or nerve transfer surgery.

Results: We identified 2,044 citations; 1,512 texts were excluded because of content, and 96 texts were screened for eligibility.

Texts were excluded if they did not report the motor score (M0 to M5 as determined by the British Medical Research Council) or measurements of range of motion of the wrist. Sixteen texts were eligible for qualitative synthesis. Outcomes of these studies show heterogeneity with regard to the technique and functional restoration.

Conclusions: On the basis of the results of this systematic review, there does not seem to be a clearly superior technique; rather, there are advantages and disadvantages to each.

Patient selection and surgeon experience are important when considering surgical interventions in this challenging clinical scenario. Nerve transfer surgery is an emerging technique that may offer patients meaningful functional gains with reduced donor site morbidity.

Level of Evidence: Level III

Irreparable radial nerve injury results in loss of wrist extension, finger and thumb extension, and reduction in grip strength. Clinical decision making regarding restoration of function depends on the cause, duration, and level of involvement.¹ Unfortunately, recovery of function

after nerve injury is not guaranteed, even in the setting of direct surgical repair.

Tendon transfers historically have been the standard surgical treatment for loss of function associated with radial nerve injuries. Although many combinations of tendon transfers and

direct nerve repair have been proposed, no clear consensus exists regarding indications, the most successful procedure or procedures, or the order of procedures.²⁻⁵ More than 90 surgical interventions involving various combinations of nerve reconstruction and tendon transfers have been described for restoration of hand function.⁶⁻¹¹ Return to activity as tolerated typically occurs 6 to 12 weeks after the tendon transfer procedure.¹²

More recently, nerve transfer procedures have gained popularity as a treatment option for radial nerve palsy.¹³ Potential benefits of nerve transfers include restoration and preservation of native muscle biomechanics without the need for healthy muscle harvest, less muscular dissection, less donor morbidity, and less adhesion formation.^{14,15} Time to return of clinically significant function in nerve transfer can extend to 1 year.¹⁶⁻¹⁸

The purpose of this systematic review was to identify and compare the outcomes of tendon transfer operations and nerve transfer operations with regard to return of wrist and finger extension after traumatic radial nerve palsy. Secondary reported outcomes were also examined, including time to surgical intervention, time to return to function, follow-up, and maximal motor strength, as defined by the British Research Council (M0 to M5).

Methods

Criteria for Eligibility

Inclusion criteria were publication within the past 50 years, publication in English, results reported in terms of motor strength (M0 to M5 based on the British Medical Research Council) or degrees of wrist extension, and level of evidence of at least IV or higher. Exclusion criteria were studies that reported finger extension but

not wrist extension, studies with duplicate patients, level of evidence V (expert opinion), animal studies, biomechanical research, and articles describing surgical techniques.

Identification of Studies

We performed a systematic review of the literature. The medical search engines used in this study included PubMed, EMBASE, and the Cochrane Database. The following terms and Boolean operators were used in each search: “radial nerve palsy” or “radial nerve paralysis” or “radial nerve injury” or “radial nerve lesion” or “wrist extension” or “finger extension” or “thumb extension” or “wrist motion” or “power grip” or “tendon transfer” or “tendon reconstruction” or “Tsuget’s procedure(s)” or “Riordan’s procedure(s)” or “reinnervation” or “nerve transplantation” or “nerve graft” or “nerve transfer” or “neurontization.” The bibliography of each article identified was also searched manually for additional further potential references.

Data Extraction

Relevant information regarding the study type, number of patients, method of treatment, and treatment results was extracted (Table 1, Supplemental Digital Content 1, <http://links.lww.com/JG9/A6>). Each eligible study was graded for the level of evidence by two authors (JO, MD), and disagreements were resolved by the third author (JC).

Results

We identified 2,044 citations with our initial search parameters. After duplicate removal, 1,608 texts remained for screening. Of note, 1,512 texts were excluded in the initial screening process because they were not applicable to the study question. Ninety-six texts were included for assessment for eligibility. Thirty-

seven texts were excluded as level V evidence. An additional 41 texts were excluded because wrist extension and the motor score were not reported. Two texts were excluded because of duplicate study subjects. Digital extension data were included when reported in conjunction with wrist functional outcomes. Thus, 16 texts were included for qualitative synthesis (Figure 1).

Characteristics of the Studies

No randomized controlled trials or nonrandomized comparative studies were identified that directly compared tendon transfer with nerve transfer surgical interventions. Of the 16 studies, no level I or level II evidence studies were identified. Six were level III evidence,^{8,19-23} and 10 were level IV evidence.²⁴⁻³³ Study designs included one prospective cohort study,²² one case-control study,²³ and four retrospective cohort studies;^{8,19-21} the remainder were retrospective case series or case reports. Two texts were abstracts.^{20,21} We identified a total of 463 patients with radial nerve palsies who underwent surgical treatment; most patients (438 [93%]) underwent tendon transfer, and 25 patients (7%) underwent nerve transfer.

Seven studies reported on outcomes of various tendon transfer techniques for restoration of wrist extension. Two texts reported outcomes of nerve transfer. Two studies reported strength as an extension force;^{30,33} two additional studies reported strength as a percentage of contralateral testing.^{19,23} In two studies, the M4 and M5 motor score was not differentiated; motor strength outcomes were reported as strength \geq M4.^{20,31}

Of the studies that reported the motor score, 99 of 106 tendon transfer patients (93%) and 24 of 25 nerve transfer patients (96%) achieved at least M3 motor function with after intervention, and 96 of 106 tendon transfer patients (91%)

achieved M4 or M5 strength with wrist extension.

Tendon Transfer for Restoration of Wrist Extension

Fourteen publications addressed tendon transfer as a method of restoring high radial nerve function (Table 1, Supplemental Digital Content 1, <http://links.lww.com/JG9/A6>). Time to surgical intervention varied from 1 month to 19 years after injury. The tendon transfer operations that surgeons chose represented a heterogeneous population of interventions; no article explicitly stated indications for one particular procedure or combination of tendon transfer procedures. The most commonly reported tendon transfers included pronator teres to extensor carpi radialis brevis, palmaris longus to extensor pollicis longus, and flexor carpi ulnaris to extensor digitorum communis and extensor indicis proprius. In studies that reported the motor score, 99 of 106 tendon transfer patients (93%) achieved at least M3 motor function in wrist extension. In studies that reported wrist extension as a metric, patients achieved a range of results from 0° to 70°. One study showed notable improvement in wrist extension over 6 years' observation, suggesting that patients continue to experience functional gains over an extended period.⁸

Twelve tendon transfer studies reported degrees of wrist extension attained, which ranged from 0° to 70°. Time to return to function, or routine daily activity, was reported in three studies^{8,27,29} at approximately 6 weeks; follow-up ranged from 6 months to 235 months.

Nerve Transfer for Restoration of Wrist Extension

Two publications reported on treatment of radial nerve palsy with nerve

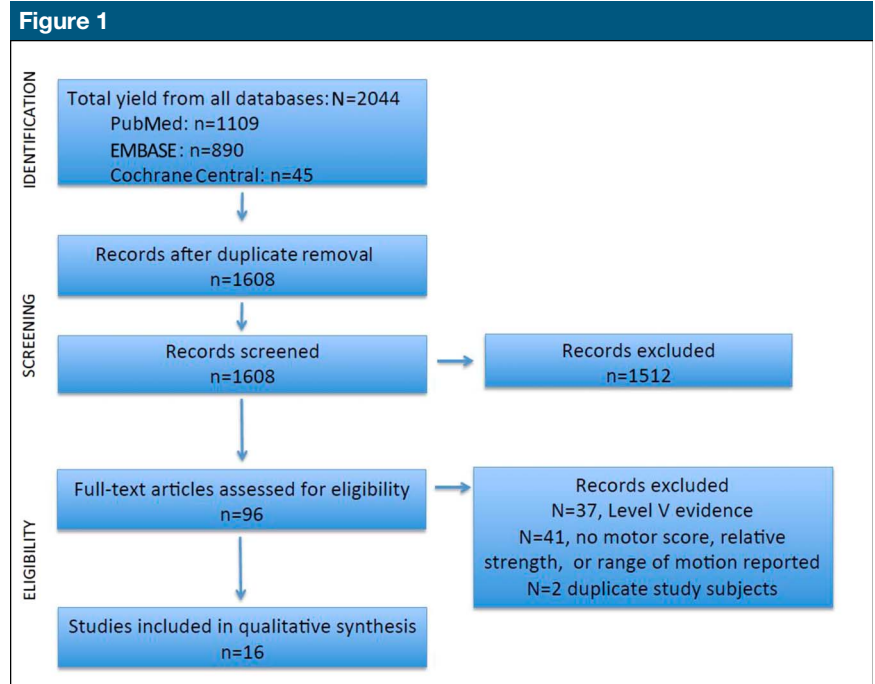


Diagram of the preferred reporting items for systemic reviews and meta-analyses. The initial search yielded 2,044 texts. After duplicate removal, 1,608 texts remained. After screening and assessment for eligibility, 16 texts were included for qualitative synthesis.

transfer (Table 1, Supplemental Digital Content 1, <http://links.lww.com/JG9/A6>). Patients underwent transfer of median nerve redundant fascicles to the posterior interosseous nerve and the extensor carpi radialis brevis³¹ or extensor carpi radialis longus.²⁶ The median time to surgical intervention was 5 months after injury in these studies. For patients who underwent nerve transfer, 24 patients (96%) achieved at least M3 wrist extension; 23 patients (92%) achieved at least M4 wrist extension. In one case report, the patient attained 70° wrist extension with a slight lag in the index finger.¹⁵ Time to return to function was not reported; however, the average reported follow-up period was 20 months.

Discussion

Most studies included for this systematic review reported on a hetero-

geneous collection of tendon transfers with a large range of outcome metrics, including motor score, degrees of wrist extension, wrist extension strength, and percent strength of the contralateral extremity. Even within the articles collected on tendon transfer, a direct comparison of patient outcomes in these studies is difficult, given differing outcome measures described. To the best of our knowledge, no method exists to directly compare the motor score reporting with degrees of wrist extension, percent strength of the other side, or Bincz scores.³⁴ In addition, data on time to follow-up, time to surgical intervention, and return to performance of activities of daily living are variably reported. This limits our ability to directly compare tendon transfer with other techniques. Major advantages of tendon transfers include widely published techniques and rapid return to function within 6 to 12 weeks. However, these techniques require sacrifice of a functional

muscle, extensive dissection, risk of restricted tendon and muscle glide due to scar formation, and loss of strength in the transferred muscle. Although tendon transfer remains the traditional surgical intervention for radial nerve injuries, there is a body of emerging data with regard to nerve transfer. Two studies examined the outcome of nerve transfer accounting for 25 of 463 patients (5%). Twenty-four of 25 patients who underwent nerve transfer regained at least M3 function, and 23 regained M4–5 function, suggesting that median nerve transfer is a promising new surgical technique for radial nerve restoration. Proponents of nerve transfer report that it can be performed without appreciable donor group weakness, and the regenerative nature of motor axons theoretically allows donor muscle to regain its original strength.³⁵ Nerve transfers may offer a greater functional gain in a single transfer instead of multiple procedures often required in tendon transfer.³⁶ Theoretically, the technique avoids disruption of the tendon-muscle unit and induces less scar formation and thus a lower likelihood of restriction in muscle and tendon gliding.^{3,37}

However, nerve transfer requires a longer recovery time, with a risk of incomplete recovery.³⁸ Nerve transfer represents a relatively new technique, and thus, long-term follow-up is not yet available. Nerve transfer for radial nerve palsy is not yet a widespread procedure, and the nerve transfers reported on have been performed at high-volume tertiary care centers with highly skilled surgeons, which could favorably bias outcomes, as seen with similarly complex procedures such as thumb replantation.³⁹

We acknowledge that our search fails to include studies not written in English or translated to English, and unpublished data. Errors in search methods may result in missing data and introduce systematic bias by exclusion. We were not able to

separate children from the cohorts described, and in some instances, we were not able to separate the type of procedure performed from the ultimate overall results of the cohort study when results were reported as a single outcome or categorically. In addition, some articles did not delineate motor scoring beyond M3 (anti-gravity) power.

In summary, the traditional treatment of loss of function associated with radial nerve palsy has been tendon transfers; however, in recent years, a growing body of literature supports median nerve transfer as a viable and exciting new alternative. A major weakness of the literature in this area is a paucity of standardized outcomes, and thus, a direct comparison of procedures is not possible based on the current evidence. On the basis of the results of this systematic review, there does not seem to be a clearly superior technique. Patient selection and surgeon experience are important when considering surgical interventions in this challenging clinical scenario.

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