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CORR Insights®: What is the Elbow Flexion Strength After Free Functional Gracilis Muscle Transfer for Adult Traumatic Complete Brachial Plexus Injuries?

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Where Are We Now?

In the past 20 years, reconstruction using extraplexal sources in transfers to reinnervate vascularized muscle and the introduction of novel distal nerve transfers have drastically changed brachial plexus surgery. Surgery involves having an array of procedures available and being able to use them appropriately; I believe we all agree with Millesi when he said, "All reasonable chances must be exploited" [5]. When it comes to complex pan-brachial plexus injuries, a surgeon must be comfortable with using a long-term, staged treatment plan such as maximum neurotization, nerve graft and transfer, free functional muscle transfer (FFMT), and comprehensive therapy and observation.

The authors' efforts in "What is the Elbow Flexion Strength After Free Functional Gracilis Muscle Transfer for Adult Traumatic Complete Brachial Plexus Injuries?" [7] have produced essential evidence to better understand the outcome of microsurgical treatment after failed attempts at primary repair or delayed presentation of a debilitating injury. This work aimed to evaluate the functional outcomes of gracilis FFMT in terms of muscle strength and ROM and performed an in-depth assessment of factors that can improve outcomes, such as the choice of distal attachment and neurovascular sources. This group cares for a high volume of brachial plexus injuries, and in that context, they demonstrated that FFMT of the gracilis muscle is a viable treatment option for patients with a flail upper limb after nonresponse to primary nerve surgery, delayed intervention, or total root avulsion. Different distal attachments to the extensor carpi radialis brevis, extensor digitorum communis and extensor pollicis longus, flexor digitorum profundus, and flexor pollicis longus and the choice of a supplying nerve (such as phrenic, accessory, or intercostal nerve) were not superior to one another. These discoveries validate the reliability of gracilis FFMT in the hands of experienced surgeons, joined with extensive rehabilitation to regain power in elbow flexion. This work has provided the details of this flap and allows the surgeon to offer more consistent and predictable results to the patient.

Where Do We Need To Go?

In 90% of patients with brachial plexus injuries, there is a need for rehabilitation of elbow flexion. For upper brachial plexus injuries, which are the most common type, as Bertelli and Ghizoni [1] described, elbow function can be restored through an Oberlin nerve transfer. Regarding total paralysis of the brachial plexus, in 88% of patients [1], there is a root that can be grafted, and reconstruction should be considered in the root not only to restore elbow flexion but also to control pain. However, root grafting with the

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elbow in flexion comes with 75% M3 + recovery and 25% failure because of poor root quality or double lesions. An intraoperative stimulation and protraction test can help assess the long thoracic nerve, and if it is better preserved, we can expect superior root quality and an improved outcome. Using a longer graft (average of 14 cm) can also help improve outcomes, but the performance of a double nerve transfer still needs more research [2, 4, 6].

In contrast, in patients with total paralysis, when there is no available root for grafting, there are nerves to transfer (such as phrenic, spinal accessory, contralateral C7, and intercostal nerves), but these patients' recovery is poor. Thus, there is a growing need for innovation in these scenarios. In patients who do not respond to primary reconstruction or have a delayed presentation, FFMT is a reliable option, and the gracilis is comparable to the biceps brachii because there is minimal donor site morbidity [3]. Muscle is healthy from the moment of surgery and may offer the advantage of improved flap coverage and, subsequently, a better outcome.

Although FFMT has evolved and become the ideal solution to improve elbow force and recover ROM [4], grasp and hand prehension remain the biggest challenge. We are aware that impairments to hand function introduce an enormous physical and psychologic burden. There are options to attempt to restore finger flexion (such as contralateral C7 nerve transfer from the affected limb [8]), but these come with greater donor site morbidity and require additional secondary procedures. They seldom, if ever, provide function that is independent from that of the opposite side. At best, the opposite hand becomes a helper hand.

With the gracilis length, a surgeon can innervate the muscle proximally and long enough to attach the muscle to the finger flexors or distally attach it to the extensor carpi radialis brevis for wrist extension, but what is the actual mechanical impact on the wrist and fingers? To this point, we have had more research on the impact of these kinds of transfers near the elbow than we have had on the hand. The next round of research needs to help us understand the effect of FFMT on the biomechanics and function of the hand.

Many patients present with stiff and dystrophic hands; even with preoperative therapy and capsulotomy, they still have considerable residual disability. FFMT cannot be performed when there is a vascular injury, which occurs in a large percentage of these patients. Moreover, patients with severe head injuries cannot cooperate with rehabilitation, or they might have a bony or soft tissue defect that hampers gliding. Further studies need to explore viable rehabilitation options in this group of patients.

Finally, there is much to learn about the functional results of FFMT. Although surgeons focus on rehabilitative approaches in order to maximize shoulder, elbow, and hand grip function, we need to know more about what patients can expect from these large surgical interventions.

How Do We Get There?

Full recovery of function after brachial plexus reconstruction is still far from reality. The idea of double FFMT and nerve transfer has been entertained before [4] in patients with poor finger ROM, but with evolving microsurgical techniques, I encourage new studies on staged double FFMT procedures. For example, to improve hand function, in the first stage, the first gracilis muscle could be used, as described [7]. In the second stage, two intercostal nerves could be transferred to the triceps motor branch and two could be transferred to the second gracilis muscle. Moreover, with myoelectric prostheses that have articulating hands, researchers could investigate the prostheses' utility in rehabilitating the hand's function in these challenging reconstructions.

In patients with total paralysis without any graftable root, we could use our knowledge in bioengineering, create a pedicled vascularized nerve graft, and introduce it to the injury zone. On the other hand, although we have not progressed substantially in recovering hand function, biomechanical cadaver studies can reveal the role of different distal attachments in the context of FFMT and their impact on wrist and hand function.

Furthermore, through using validated questionnaires or interviews, assessing patients' goals and perceptions about their disabilities can increase our understanding of how to prepare and motivate our patients for the aftercare that is so important after these procedures. Likewise, we need to ensure that robust social support systems can assist our patients in the arduous recovery process. It is crucial to educate our patients that inattention to or incomplete rehabilitation can result in worse postoperative outcomes than intended.

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