The use of perforator radial fascial forearm flap in the management of recurrent carpal tunnel syndrome

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Background
Management of recurrent carpal tunnel syndrome is considered a challenge for hand surgeons. We treated this clinical entity using a novel technique involving pedicled tissue transfer using a perforator-based radial-sided fascial forearm flap.

Patients and methods
The procedure was performed in six patients, all of whom had undergone previous failed surgery to release the median nerve and a period of initial relief not less than 3 months.

Results
At an average of 24 months following the procedure, all patients reported symptomatic improvement with complete resolution of night-time symptoms. No patient reported worsening of symptoms postoperatively; however, subjective paresthesias persisted in three of the six patients. Objective assessment revealed complete resolution of Tinel's sign in half of the patients and significant improvement in the other half. The average two-point discrimination improved from 10 mm preoperatively to 6 mm postoperatively, and the average postoperative grip strength improved from 11 to 20 kg.

Conclusion
The radial perforator-based fascial forearm flap is a useful option in the management of selected patients with recurrent carpal tunnel syndrome.

Keywords:
carpal, flap, perforator, tunnel

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Introduction

Recurrent carpal tunnel syndrome is defined as symptoms that return after a period of relief following primary carpal tunnel release. Recurrent carpal tunnel syndrome occurs in 0.3–20% of patients after primary carpal tunnel release [1]. In such patients, revision surgical decompression offers less reliable resolution of symptoms [2]. The principles of management include repeat release of the median nerve with excision of the excessive scarring, with some advocating microscopic neurolysis and coverage with vascularized tissue to allow better nerve glide and vascularity [3]. Such principles have led to the development of tissue transfer procedures. Popular procedures such as the hypothenar fat-pad flap [4] offer a good option for such patients and can be performed through limited approaches, which only nominally lengthen the scar from the initial procedure. The hypothenar fat pad does not allow the coverage of a large area of scarring over the median nerve and therefore may be the simplest option in some cases in which scarring is confirmed to the carpal tunnel. Other options such as the pedicled radial artery-based forearm flap offer a potentially large amount of vascularized tissue for transfer to the area over the carpal tunnel at the expense of added bulk and the sacrifice of a major vessel in the forearm [1]. Some have advocated using radial artery-based forearm flap [1,5,6], ulnar artery-based forearm flap [7,8], or vascularized free tissue transfer [1,9,10] to accomplish the goals of providing healthy tissue to the scarred area over the median nerve. Through this prospective cohort study, we offered an intermediate solution that could cover a potentially larger area compared with the hypothenar fat-pad flap while sparing the radial and ulnar arteries in the forearm. We hypothesized that a perforator radial-based fascial forearm flap could be designed so that it could be mobilized over the median nerve in a pedicled manner. This flap has been described in the setting of trauma to cover soft tissue defects in the hand [11,12], and we extend its application to manage cases with scarred area after rerelease of recurrent carpal tunnel syndrome.

Patients and methods

In this study we included six patients (five female and one male) who reported initial recovery of 3 months or more after open carpal tunnel release. The average age was 39.4 years (range 28–50 years). Two patients had undergone at least one revision surgery and the remaining patients had only undergone the index procedure. In patients with a previous revision surgery, the choice of coverage with the perforator-based radial

forearm fascial flap was made preoperatively based on the number of previous procedures. In the remaining four patients, the decision to use this flap was made based on the intraoperative findings of scarring, which extended proximal to the carpal tunnel into the distal forearm. All patients who underwent the procedure were found to have extensive scarring over the median nerve, extending proximally into the distal forearm. Patients with epineural scarring confined to the area of the carpal tunnel were excluded from this study and were treated with other procedures.

The flap is planned on the basis of six to 10 septocutaneous distal perforators of the radial artery, which originate from the radial and ulnar sides of the artery ending 1.5 cm proximal to the radial styloid. These perforating arteries are separated from each other by 0.4–1.5 cm and have an outer diameter ranging from 0.3 to 0.8 mm, with longitudinal branching and transverse connections [11,12]. The pivot point is the most proximal perforator located 5–8 cm proximal to the radial styloid and the distal reach is the distal extent of the scarred tissue in the carpal tunnel.

After revision release of the transverse carpal ligament or its remnant, all patients underwent neurolysis using loupe magnification. Intrafascicular dissection was performed in two patients, and one patient required formal internal neurolysis using a standard operating microscope. This patient was discovered to have some interrupted fascicles — attributable to the previous procedures. Additional tenolysis of structures in the carpal tunnel was necessary in three of six patients. The incision was extended ulnarly at an angle of 30°–60° into the distal forearm (proximal to the proximal wrist crease) in all patients to complete neurolysis or tenolysis procedures. In two patients with a wound already extended, the previous incision was not extended. The palmar cutaneous branch was found injured in two patients.

In three patients, a second curvilinear incision was made directly over the planned flap centered on the distal radial artery with its known fixed perforator ~5–8 cm proximal to the radial styloid. Through this curvilinear incision, skin was undermined in the plane of loose areolar connective tissue superficial to the fascia. Thereafter, the fascia was raised over the flexor carpi ulnaris and extended radially to the level of the perforators. The radial side of the flap extends from the fascia over the extensor carpi radialis brevis to the level of the perforators. Care was taken not to injure the lateral cutaneous nerve of the forearm during the subcutaneous dissection and the superficial radial nerve when raising the fascia at the level of the posterior border of the brachioradialis. Finally, dissection was performed from the proximal to distal direction separating the fascia from the proximal radial artery with ligation of spare perforators at this level. The flap was then rotated 180° to reach the distal extent of the carpal tunnel to cover the median nerve.

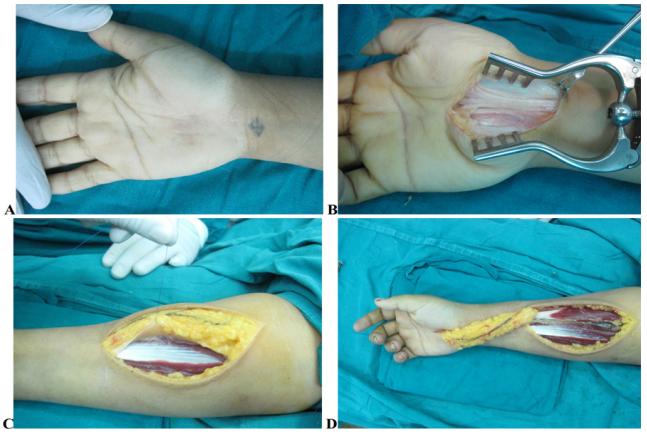
The fascial flap was then sutured to the distal extent of the carpal tunnel so that it lay under no tension over the median nerve and the skin was closed. In three of six patients, the flap was tunneled beneath an intact skin bridge in the distal forearm, and, in the remaining three, a single incision contained both the flap donor and recipient sites. In two patients the fat content of the adipofascial flap required debulking (Fig. 1).

Results

Six patients with recurrent postoperative carpal tunnel syndrome were included in this series. All patients had a symptom-free interval of at least 3 months after the first carpal tunnel release (mean 4.5 months, range 3–6 months). Of the six patients included in this study, four had undergone only one previous surgery (index carpal tunnel release performed using the open approach). One patient had undergone one revision in addition to the initial carpal tunnel release with a postrevision surgery symptom-free interval of 4 months. The final patient had undergone two revisions with no improvement after either revision procedure. Only one patient was diabetic and no patients were suffering from any other chronic illness or peripheral nerve affection or inflammation.

All patients underwent electrodiagnostic testing, including nerve conduction and electromyographic

Figure 1



(a) The scar of the previous release. (b) The median nerve after interfasicular dissection through extended approach. (c) Harvesting of the adipofascial flap through a separate curvilinear incision. (d) Rotated flap before debulking and tunneling showing the distal reach of the flap.

studies. Four of six patients had moderate findings on electrodiagnostic studies and the other two of six were graded as severe on the basis of the classification scheme published previously [13].

Patients were followed up for an average of 24 months (range 18–30 months) at weekly interval for 4 weeks and then at monthly interval for five more months, followed by 3 months' intervals. No patient reported dissatisfaction or worsening of symptoms postoperatively. Clinically, five patients' night-time symptoms were fully resolved by an average of 3 weeks and improved in the other one. Patients reported near-complete resolution of paresthesias and numbness by 16 weeks; however, occasional paresthesias persisted in two patients and full time paresthesias in one patient. Numbness disappeared in four patients, persisted in the palm only in one patient, and persisted in the index, middle finger, and palm in one patient. Objective assessment revealed that the Tinel's sign was fully resolved in three patients and had improved in the other three. Phalen sign disappeared in all patients. The average two-point discrimination improved from 10 mm preoperatively to 6.25 mm postoperatively as measured in the index finger of each operative hand. The average postoperative grip strength as measured on a standard Jamar dynamometer improved from 11.25 to 20.25 kg.

Using the grading system suggested by Luchetti *et al.* [2] we achieved an outcome of two excellent, three good, and one fair result.

Patients continued to improve over 12 months after surgery and then reached a plateau after which no clinical improvement was noted. Two patients required gabapentin 75 mg twice daily for 6 months.

Discussion

We agree with most authors [1,3,9] in that if fibrosis is confined to the vicinity of the carpal tunnel during the revision surgery, simple solution such as a fat flap or synovial flap usually results in a satisfactory outcome. Hence, we performed the perforator-based radial fascial forearm flap for selected situations in revision carpal tunnel surgery when patients had either already undergone revision of the index procedure or fibrosis around the median nerve was found to extend proximally into the distal forearm impairing its vascularity and gliding. If fibrosis found at the time of surgery was limited to the carpal tunnel, our practice continued to focus on neurolysis with or without fat pad or synovial flap coverage of the median nerve, which provides reliable symptomatic relief with little additional dissection [3,4,10].

In patients with extensive scarring or previous revision surgery for persistent or recurrent carpal tunnel syndrome, we have found favorable results with the perforator-based flap when measured using a standard grading system previously published by Luchetti *et al.* [2]. Using this system, a result is considered as excellent in those patients who had a complete relief of symptoms, a normal postoperative two-point discrimination value, and return to prior work level. A good result is achieved when, despite persistent mild pain, symptoms are not severe enough to impede the full use of the hand and when numbness and scar tenderness are considered mild by the patient. A fair result demonstrates a reduced level of pain and paresthesia compared with preoperative symptoms. We had only one diabetic patient, who achieved fair result in two previous revisions; the rest of the patients in this small series achieved good or excellent results.

There are many potential advantages to this approach. The fascial flap based on a perforator is much less bulky with less interposed tissue over and inside the carpal tunnel. It may be interposed between the nerve and the superficial structures such as the remnants of the transverse carpal ligament and the skin. Alternatively, the flap can be designed to envelop the nerve or lie between the nerve and the deeper flexor tendons. Moreover, the approach allows for the additional ability to release and address distal forearm pathology. On the basis of the relatively fixed anatomy of the perforators, there is no need to sacrifice the radial artery, and the reach of this local flap can extend to the distal part of the transverse carpal ligament with relative ease.

The perforator-based radial fascial forearm flap is a useful option in the management of recurrent carpal tunnel syndrome. In our limited operative experience, this procedure provides reliable relief of symptoms in many patients and may be uniquely suited to treat recurrent carpal tunnel syndrome in cases where a larger length of the nerve is involved.

Conclusion

The perforator-based radial fascial forearm flap is a useful option in the management of recurrent carpal tunnel syndrome with scarring extending to the distal forearm. Further studies will be needed to compare the results of this procedure with other classically described means of treating recurrent carpal tunnel syndrome.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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