The functional value of a hand can be destroyed by pain. One of the most common causes for such pain-induced disability is the presence of a neuroma entrapped in a palmar cutaneous scar, as seen following carpal tunnel surgery or median nerve repair at the wrist. There remains a subgroup of patients whose neuromas in this area do not respond to the usual attempts at therapy: desensitization, steroid injection, neurolysis, and neuroma resection. Because the median nerve and its palmar cutaneous branch lie so close to the skin at the wrist level, postoperative adherence of an atrophic, multiply operated dermis and subcutis to these nerves is difficult to avoid. Interposition of an abductor digiti minimi muscle flap between skin and nerve in this region has been reported once for treatment of cicatricial median and ulnar neuritis in 1977. More than 50 years ago, Huber and Nicolaysen utilized the abductor digiti minimi muscle for an opponensplasty. This technique was reemphasized by Littler and Cooley in 1963, and again recently. We report our experience employing this muscle flap about the wrist as an adjunct salvage procedure to the treatment of the underlying neurologic problem.

**Patient Population**

Twelve patients with incapacitating pain due to volar wrist injury or surgery were selected as candidates for an abductor digiti minimi muscle flap (ADMMF) operation based on their failure to achieve relief of pain and regain hand function after at least 6 months of therapy. This therapy included desensitization and usually at least one previous neurolysis and/or neuroma resection. A clinical outline of this group is presented in Table I. Two typical patients are described below.

**Case Reports**

**Case 3**

This 30-year-old woman sustained a complete division of her median nerve at the wrist associated with division of flexor tendons, all of which were repaired primarily in July of 1978. The median nerve repair was epineural. The palmar cutaneous nerve was not repaired. In February of 1980, the patient had a median neurolysis. She was referred to us 3 months thereafter, at which time the dysesthesia over her wrist was such that she could not wear a watch or bracelet. Her shirt sleeve touching her wrist caused pain. Either direct pressure or light stroking of her wrist produced dysesthesia and pain. She had recovered 13 mm static and 5 mm moving two-point discrimination.

In November of 1980, the abductor digiti minimi muscle flap was done (Fig. 1). The muscle was partly denervated. Microsurgical internal neurolysis of the median nerve was done, as well as resection of the palmar cutaneous neuroma. By the time the sutures were removed, it was clear that the pain on palpation of the patient’s volar wrist was greatly reduced. She was placed on a program of sensory reeducation. At her last office visit, 34 months postoperatively, she had full wrist movement without pain. The volar skin could be pressed without discomfort (Fig. 2). Static two-point discrimination was 8 mm, and moving two-point discrimination was 4 mm. The patient is now able to carry out all her daily activities as a homemaker.

**Case 4**

This 38-year-old secretary developed a carpal tunnel syndrome in her dominant hand. The deep transverse carpal ligament was divided in December of 1973, but symptoms persisted. The patient had an internal neurolysis of the median nerve in December of 1976 with subsequent development of dysesthesia in the volar wrist skin. A painful area in the scar persisted. The numbness in the patient’s finger continued. At the time she was referred to us in November of 1980, she had absent static and moving two-point discrimi-
TABLE I
Clinical Details of Group

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Clinical History</th>
<th>Date of ADMM Flap</th>
<th>Length of Follow-Up</th>
<th>Pre-operative</th>
<th>Post-operative</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34</td>
<td>M</td>
<td>Primary repair median, 6/77</td>
<td>12/79</td>
<td>7 mo.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>M</td>
<td>Crush injury with primary repair median, 5/78</td>
<td>1/80</td>
<td>6 mo.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>F</td>
<td>Neurolysis median nerve, 6/78</td>
<td>11/80</td>
<td>34 mo.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>38</td>
<td>F</td>
<td>Carpal tunnel release, 12/73</td>
<td>12/80</td>
<td>33 mo.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>23</td>
<td>F</td>
<td>Partial median transaction, 6/81</td>
<td>2/81</td>
<td>31 mo.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>42</td>
<td>F</td>
<td>Carpal and guyon canal releases, 1974</td>
<td>2/82</td>
<td>19 mo.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>F</td>
<td>Median and ulnar neurolysis, 9/81</td>
<td>2/82</td>
<td>19 mo.</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>47</td>
<td>F</td>
<td>Partial median transaction, 8/79</td>
<td>3/82</td>
<td>18 mo.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>52</td>
<td>M</td>
<td>Puncture wound, multiple 1 and Ds to palm, 10/79</td>
<td>4/81</td>
<td>29 mo.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>38</td>
<td>F</td>
<td>Carpal tunnel release, 1966, 1968</td>
<td>1/82</td>
<td>19 mo.</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>40</td>
<td>M</td>
<td>Carpal tunnel release, 1980</td>
<td>6/81</td>
<td>26 mo.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>35</td>
<td>F</td>
<td>Carpal tunnel release, 1980</td>
<td>8/81</td>
<td>24 mo.</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

As the muscle is reflected proximally to its origin from the pisiform, care must be taken on its radial side, where the neurovascular bundle originates, in order not to devascularize the flap. As the muscle origin from the ulnar and distal sides of the pisiform is released, the muscle arc of rotation increases. The muscle is transferred across the carpal tunnel and spread out over the median nerve. The muscle bulk should be interposed between the area of dysesthetic skin, the palmar cutaneous branch of the median nerve, and the length of median nerve that is neurolyzed. The muscle is splayed out to its natural rectangular shape (Figs. 1 and 3) and, by means of its tendinous distal end, is sutured to the ulnar border of the transverse carpal ligament and/or the tendon sheath of the flexor carpi radialis.

Before doing the muscle dissection, a microsurgical internal neurolysis of the median nerve and a thorough tendolysis are done. Neuromata of the palmar cutaneous branch of the median nerve or within the median nerve itself are resected so that the resected ends will be related to muscle.

RESULTS
Patients were graded as follows:

1. Severe pain with hand function resulting in inability to perform daily activities
tually complete relief of pain in the patient's opinion and if direct stimulation of the wrist by the examiner no longer produced the preoperative pain (Fig. 2). Good results were judged to have occurred if some residual dysesthesia remained, but it was insufficient to limit hand function. Fair results were judged to have occurred if dysesthesia was improved but hand function remained impaired because of the residual dysesthesia. Poor results were judged to have occurred if there was no improvement following surgery or symptoms were worse.

All patients were improved following the abductor digiti minimi muscle flap procedure combined with appropriate neurolysis or neuroma resection. Seven of the 12 patients have returned to their original jobs (patients 1 through 4 and 10)

2. Moderate pain significantly limiting work and limiting activities
3. Mild or occasional pain with hand function, but patient is able to work and perform all daily activities
4. No pain with wrist flexion or extension or palpation of the wrist and patient is able to work without pain

In terms of relief of the dysesthesia, a patient was judged to have excellent results if there was vir-

Fig. 1. Case 3. Intraoperative views. (Above) Painful incontinuity neuroma. (Center) Muscle flap elevated. (Below) Pennate muscle opened out to rectangular shape covering neuroma proximal to wrist.

Fig. 2. Case 3. Postoperative views. (Above) Demonstration of applied pressure to previously dysesthetic region. (Center and below) Appearance of hand 18 months after surgery.
two patients were affected adversely by loss of the abductor digiti minimi muscle function. Most were still able to abduct the little finger either due to residual hypothenar muscle function or a slip of the extensor digiti minimi inserting into the ulnar side of the proximal phalanx of the little finger.

**Discussion**

The results of interposing the abductor digiti minimi muscle between dysesthetic volar wrist skin and the injured and neurolyzed median nerve have been highly successful in terms of relief of pain and restoration of hand function. One hundred percent of the patients received some and 92 percent of the patients received good or excellent relief of pain. The one patient who achieved only a fair result (patient 5) had median nerve injury that extended proximal to the area covered by the abductor digiti minimi muscle flap. In retrospect, patients with median nerve injury proximal to the wrist are not candidates for an isolated abductor digiti minimi muscle flap, but should have a pronator quadratus muscle flap. For an extensive nerve injury, the two flaps may be combined to provide coverage for the entire length of the injured nerve.

The entire area of the relationship between muscle and injury, is currently receiving increased attention for problems such as radiation ulcers, osteomyelitis, and capsular contracture about breast implants. The possible nutritive or trophic effect of muscle on injured sensory nerve remains to be elucidated. Another relevant question for the abductor digiti minimi muscle flap is should the muscle flap remain innervated to provide maximal interposed bulk, or would denervation induce changes in the muscle that might "attract" sensory axons and minimize neuroma formation? This question may be pursued best in an experimental model. There appeared to be no difference in the results between two patients whose muscle was intentionally partially denervated (patients 3 and 4) and those whose muscle flap remained normally innervated. At present, our preliminary clinical and experimental work suggests that the best result will occur after neu-
roma resection, not by simply covering the transected sensory nerve end with the muscle, but by implanting the transected nerve end into the muscle.\footnote{16}

We emphasize that the abductor digit minimi muscle flap is neither the primary nor the sole treatment of palmar pain of neural origin, but rather an adjunct to a meticulous neurolysis of the median nerve and resection of cutaneous neuromata. We emphasize further that the procedure should be employed by those appropriately trained to do this type of surgery.

**SUMMARY**

In a series of 12 patients incapacitated by persistent or recurrent pain in the palmar aspect of the hand and wrist, successful rehabilitation was aided by employing an abductor digit minimi muscle flap. It is emphasized that this muscle flap was utilized as an adjunct to microsurgical internal neurolysis and neuroma resection. Eleven of the 12 patients (92 percent) achieved good to excellent results in terms of relief of pain, plus either return to their previous job or vocational rehabilitation. The “salvage” nature, donor-site morbidity, and technical demands of the procedure are emphasized.

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**REFERENCES**

Discussion

The Abductor Digiti Minimi Muscle Flap: A Salvage Technique for Palmar Wrist Pain

by Neal R. Reisman, M.D., and A. Lee Dellon, M.D.

Discussion by Richard J. Smith, M.D.

The recurrent neuroma or painful scar too often poses an insoluble therapeutic problem in hand surgery. Even the most skillfully reconstructed limb is ignored by the patient who finds touch unpleasant and grasp painful. Attempts to solve these problems have involved many types of treatment. Patients have received psychotherapy, physiotherapy, electrotherapy, and hydrotherapy. Their wounds have been excised, blocked, flapped, and massaged. Their neuromas have been transposed, injected, cauterized, tied, sutured, tapped, and wrapped. Each of these methods has had some success. None offers a predictable cure.

Drs. Reisman and Dellon have suggested another form of treatment. They transfer a vascularized flap of abductor digiti minimi muscle (which they call the abductor digiti minimi muscle flap) superficial to the median nerve and its palmar cutaneous branch and deep to the skin. This is similar to a procedure described in 1977 by Milward, Stott, and Kleinert, who reversed the direction of the abductor digiti minimi muscle so that it would cover a tender median nerve that lay under "densely scarred skin on the palmar surface of the wrist." Drs. Reisman and Dellon refer to no other papers describing the use of abductor digiti minimi muscle in the treatment of painful scars and neuromas.

The authors have used this flap in 12 patients with painful volar wrist scars. Eight have become pain-free, and three have only mild or occasional pain. Only one patient remains disabled because of continued pain. This is an enviable record, and it is particularly impressive because all patients had "at least 6 months of therapy . . . (including desensitization) and usually at least one previous neurolysis and/or neuroma resection."

Unfortunately, it is not possible to be certain whether the abductor digiti minimi muscle flap deserves major credit for these excellent results. The two cases described in detail (cases 3 and 4) both were cured after the flap procedure was combined with other more standard techniques. These patients had muscle flap and microsurgical internal neurolysis and resection of the palmar cutaneous neuroma. The authors do not describe what concomitant procedures were performed with the other nine successful cases. Thus we remain uncertain as to whether success of the operation is due to the muscle flap, the excision of the neuroma, or internal neurolysis done meticulously by experienced hand surgeons. Perhaps all should share the credit equally.

There is some risk in transferring abductor digiti minimi muscle to treat a painful neuroma of the median nerve or its palmar cutaneous branch. Weakened flexion of the little finger after transfer of the abductor may be of significance in a hand with median nerve paralysis. Even more important, however, is the risk of additional scarring and pain in the palm if the muscle flap becomes ischemic and fibrotic. Certainly the muscle must atrophy in its new position, even if its nerve remains intact. I wonder how much protection it offers after it atrophies. If the rather generous palmar incision required to expose abductor digiti minimi muscle becomes painful, or if the sensory branches of the ulnar nerve are injured, a difficult problem has become hopelessly compounded.

One might be wise to reserve the use of this
flap for those patients in whom a neuroma of the median nerve or its palmar cutaneous branch has not responded to more standard procedures. If the skin overlying the neuroma is thin, atrophic, and adherent to the underlying nerve, Drs. Reisman and Dellon have shown us that the abductor digit minimi muscle flap plus careful internal neurolysis and neuroma excision may give us a happy patient. We will be grateful if our results match theirs.

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