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A comparative study between local muscle flaps and hypothenar fat pad flap in management of recurrent carpal tunnel syndrome

Research Article

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Abstract

Background: Carpal tunnel syndrome, the most common peripheral neuropathy, results from compression of the median nerve at the wrist. Unfortunately, persistence of symptoms or recurrence of carpal tunnel syndrome is frequent after surgical decompression. In such cases, the median nerve needs to be covered with a vascularized tissue to prevent recurrence of the adhesions. Local muscle or fat flaps like the abductor digiti minimi, pronator quadratus, palmaris brevis and hypothenar fat flap can be used after neurolysis to cover the median nerve.

Methods: This study was carried out between May 2015 and September 2016 over 20 patients. The patients were classified into two groups according to the type of the flap coverage of the median nerve [in a random pattern]. The hypothenar fat pad flap was used to cover the median nerve in 10 patients in group A. In group B, local muscle flaps were used in another 10 patients [the abductor digiti minimi muscle flap was used in 6 while the palmaris brevis muscle flap was used in 4 patients].

Results: The mean motor nerve latency postoperatively was 4.28 ms ± 0.85 and 3.97 ms ± 0.68 in group A and group B respectively. The mean sensory nerve latency postoperatively was 3.27 ms ± 0.84 and 3.05 ms ± 0.80 in group A and group B respectively. When comparing the postoperative mean motor nerve latency of the median nerve of the operated hands in both groups and also the postoperative mean sensory nerve latency in them; the P-value of t-test for them was 0.381 and 0.544 respectively [>0.05].

Conclusion: There is no statistically significant difference between both types of flaps regarding the results of the postoperative nerve conduction studies and subsidence of the symptoms and signs of the patients.

Introduction

Carpal tunnel syndrome is the most common peripheral neuropathy. It results from compression of the median nerve at the wrist. It classically presents with pain, numbness and tingling in the median nerve distribution of the hand. When non operative means fail, it can be treated surgically by releasing the transverse carpal ligament [TCL]. This results in improvement of symptoms and return of normal sensation. On the other hand, release of the TCL may lead to scarring of the nerve and suffering from chronic pain as a result of loss of nerve sliding during wrist movements. So, persistence or recurrence of signs and symptoms of the carpal tunnel syndrome can still occur [1].

Persistence of the preoperative symptoms occurs when the transverse carpal ligament is not completely released [2]. On the other hand, recurrence can be clinically diagnosed when the symptoms disappear immediately postoperative, but then recur after six months or more [3].

Recurrent carpal tunnel syndrome can be attributed to soft tissue adhesion to the median nerve, epineural fibrosis and interstitial scar formation [4,5]. This surrounding fibrous tissue when becomes adherent to the surface of the median nerve, it develops what is called traction neuropathy with subsequent repeated wrist movements [6,7]. This prevents normal gliding of the nerve during wrist flexion and extension. There are many precipitating factors such as poor hemostasis and prolonged immobilization [3].

Surgical treatment of recurrent carpal tunnel syndrome includes, in addition to repeated median nerve decompression, external and /or internal neurolysis [8]. In general, neurolysis helps restoration of normal nerve gliding after release of the perineural fibrosis. In some studies, the value of internal neurolysis in these cases is questionable [9,10]. Other studies concluded that it may be valuable when intrafascicular scarring is present [11].

Post-operative results of neurolysis alone are not satisfying, so it is recommended by most authors to be followed by median nerve coverage using a vascularized tissue [8]. This important step has three advantages. First, this well vascularized tissue may improve the nerve microcirculation,

bringing more nutrients, enhancing nerve regeneration and restoring normal nerve gliding [12]. Second, some studies proved that there is less incidence of scar tissue formation around the nerve when covered with a muscle flap than if left close to the overlying skin [13]. Finally, this vascularized tissue serves as a mechanical barrier between the two leafs of the released TCL to prevent them from scarring and provides a cushion over the median nerve to decrease pillar pain [14].

Options for median nerve coverage with a flap include local, regional or distant options. Local options include synovial flap, hypothenar fat pad flap, lumbrical muscle flap, palmaris brevis muscle flap and abductor digiti minimi muscle flap. Regional flaps consist of reversed radial forearm flap and distal ulnar adipofascial flap. Distant options include pedicled groin flap and free tissue transfer [15].

Patients and methods

20 patients; 14 females and 6 males, were admitted to the plastic surgery department, Mansoura University in the period between May 2015 and September 2016. Their age ranged between 28-65 years. All cases were diagnosed as recurrent carpal tunnel syndrome. This diagnosis was confirmed after good history taking, thorough physical examination and recent nerve conduction studies. The operated hands were 8 left and 12 right hands. The number of recurrences was one in 15 patients, two in 4 patients and three times of recurrences in one patient. All of them had symptoms free interval of at least six months after the primary CTR surgery.

Full history was taken from all the patients. The main complaint was pain, tingling and numbness of the median nerve distribution of the affected hand. The provocation tests, including Tinel's test, Phalen's test and Durkan's compression test, were positive in all the patients. Preoperative median nerve conduction study showed prolonged latency in both motor and sensory values in all the patients. Well detailed information were discussed with patients including surgical details, the possible donor site morbidity and the other complications related to the surgical procedure.

The patients then were classified into two groups according to the type of flap coverage of the median nerve [in a random pattern]:-

1- Group A [hypothenar fat pad flap group]:-

Ten patients were included in this group with mean age of 40.6 [28-59] years. They were 7 females and 3 males. The affected hands were 7 right and 3 left hands. The time elapsed since the last operation was 8.5 [6-12] months. Number of recurrences was one in 7 patients and two in 3 patients.

2- Group B [local muscle flap group]:-

Ten patients were also included in this group with mean age of 43.7 [28-65] years. They were 7 females and 3 males. The affected hands were 5 right and 5 left hands. The time elapsed since the last operation was 8.3 [6-11] months. Number of recurrences was one in 8 patients, two in 1 patient and three in 1 patient. The abductor digiti minimi muscle flap was done for six patients while the palmaris brevis muscle flap was done for four patients.

Surgical procedure

Supraclavicular nerve block or general anesthesia was used. A tourniquet was used after adequate maintained compression from the hand to above the elbow for 5 minutes. The old scar of the previous carpal tunnel release incision was used but with more proximal and distal extension to exposed the median nerve more proximally and distally. Another incision may be added according to the type of the flap elevated. Perineural fibrosis was found making the median nerve adherent to the surrounding tissues and limiting the nerve mobility and gliding. This overlying scar tissue was removed to release the nerve. Such external neurolysis was found to free the nerve from any surrounding scar tissue making it completely mobile. Then, a vessel loop was placed around the nerve [Figure 1]. Internal neurolysis was not performed in any of our patients. The next step was covering the median nerve with a vascularized tissue marking of the muscle and the incision over the previous CTR incision plus a transverse incision over the wrist flexion crease (Figure 2).

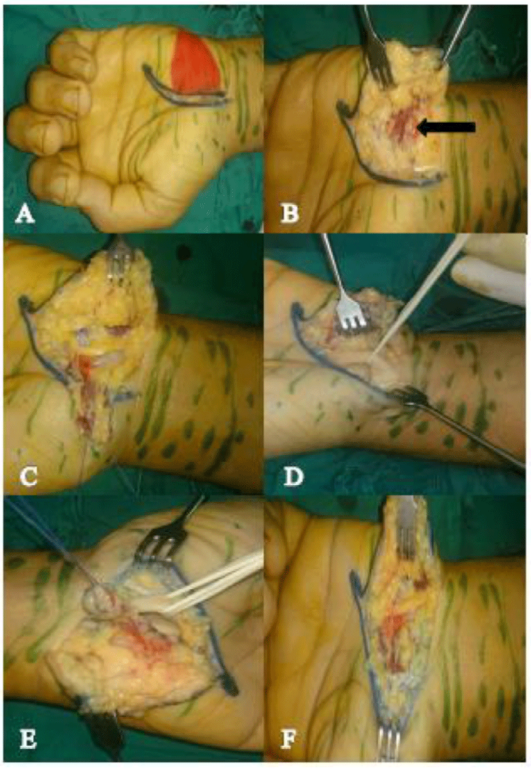

Figure 1. Female patient aged 56 years old with recurrent CTS of the left hand treated with palmaris brevis muscle flap coverage of the median nerve. (A) The preoperative marking of the muscle and the incision over the previous CTR incision plus a transverse incision over the wrist flexion crease. (B) Identification of the palmaris brevis muscle (arrow). (C) Dissection of the muscle and its detachment from its insertion. (D) Complete release of the median nerve from the surrounding adhesions (external neurolysis). (E) Transposing the muscle as a leaf like to cover the median nerve. (F) Suturing the muscle to the radial remnant of the TCL over the median nerve.

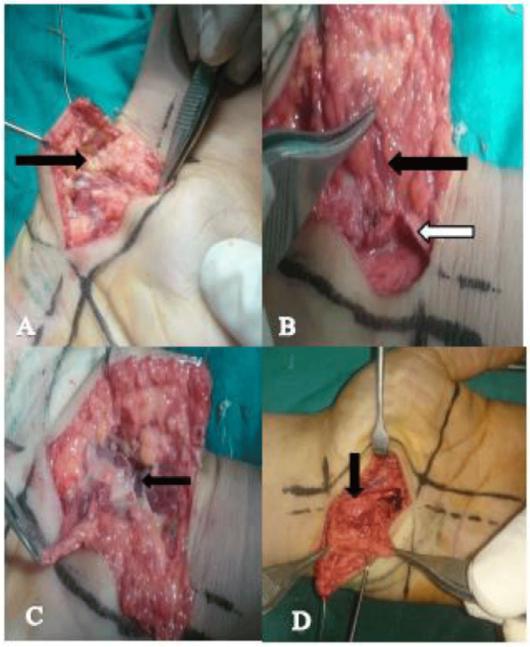

Figure 2. 28 years old female patient presented with recurrent CTS of the left hand who was treated with hypothenar fat pad flap coverage of the median nerve. (A) Sharp dissection between the hypothenar fat and the overlying skin till reaching ulnar to the insertion of the palmaris brevis muscle (arrow) with preservation of some fat attached to the skin. (B) Dissection of the hypothenar fat pad off the ulnar leaf of the TCL (white arrow) showing one of the perforators of the hypothenar fat (black arrow). (C) Elevation of the hypothenar fat pad flap off the hypothenar muscles showing another perforator (arrow) and making the flap suspended only on a vascular mesentry. (D) The hypothenar fat pad flap before covering the median nerve (arrow).

Group B included 10 patients who had median nerve coverage using a local muscle flap. In this study, one of two muscle flaps was used either the abductor digiti minimi [ADM] muscle flap [done for 6 patients] or the palmaris brevis muscle flap [done for 4 patients].

Regarding the ADM muscle flap, another incision was done over the ulnar border of the hand. The muscle was identified being the most ulnar one of the hypothenar muscle group. The muscle was then detached from its origin and insertion with preservation of the muscle pedicle which lies 1 cm distal and 1 cm lateral to the pisiform bone. The muscle was then passed under a subcutaneous tunnel

over the median nerve to be sutured to the radial remnant of the TCL [Figure 3-C] and the skin was closed primarily over it. In two cases, a small incision over the insertion of the ADM muscle was done and the muscle was detached from its insertion only and then dissected along its entire length using blunt dissection. The muscle was then passed through a subcutaneous tunnel over the median nerve [Figure 4].

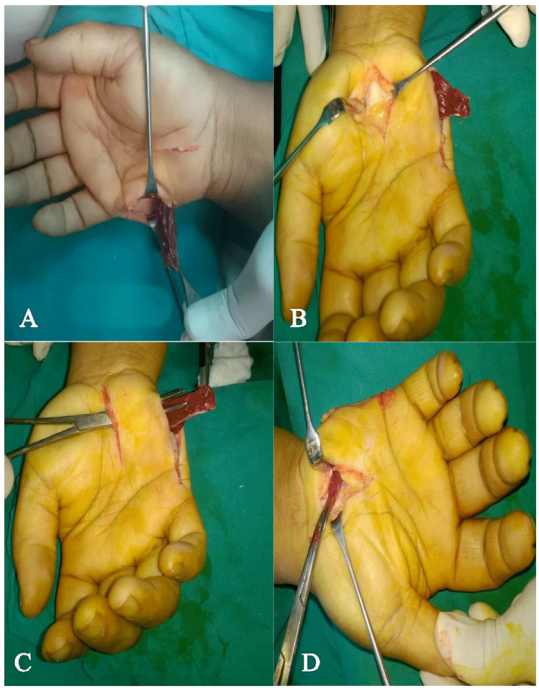

Figure 3. Female patient aged 28 years old presented with recurrent CTS of her right hand and treated with median nerve coverage using the ADM muscle flap. (A) Showing the 2 incisions, the first over the carpal tunnel for release of the median nerve from the adhesions and the second over the ulnar side of the hand for dissection of the ADM muscle as shown. (B) After dissection of the muscle which was brought out of the wound. (C) Creation of a subcutaneous tunnel through which the muscle was passed. (D) Coverage of the median nerve with the ADM muscle in the carpal tunnel.

[A] Showing the 2 incisions, the first over the carpal tunnel for release of the median nerve from the adhesions and the second over the ulnar side of the hand for dissection of the ADM muscle as shown. [B] After dissection of the muscle which was brought out of the wound. [C] Creation of a subcutaneous tunnel through which the muscle was passed. [D] Coverage of the median nerve with the ADM muscle in the carpal tunnel. [A] Passing a dissection forceps through the CTR incision to confirm complete release of the adhesions over the nerve. [B & C] Detachment of the ADM muscle from its insertion through a Z-shaped incision placed over it and then dissection of the muscle through the same incision. [D] Passing the muscle after its dissection through a subcutaneous tunnel into the carpal tunnel before its suturing over the median nerve. [E] The patient can abduct her little finger at the 3rd week follow-up.

Figure 4. Female patient aged 29 years old complaining of recurrent CTS of the right hand treated with ADM muscle flap coverage of the median nerve. (A) Passing a dissection forceps through the CTR incision to confirm complete release of the adhesions over the nerve. (B & C) Detachment of the ADM muscle from its insertion through a Z-shaped incision placed over it and then dissection of the muscle through the same incision. (D) Passing the muscle after its dissection through a subcutaneous tunnel into the carpal tunnel before its suturing over the median nerve. (E) The patient can abduct her little finger at the 3rd week follow-up.

Regarding the palmaris brevis muscle flap, we had done a transverse incision over the wrist flexion crease extending from the CTR incision in an ulnar direction. The palmaris brevis muscle was identified as a thin broad sheet with its muscle fibers running in a transverse direction. Then, it had been detached from its insertion in the dermis of the skin of the ulnar side of the hand. After that, it was

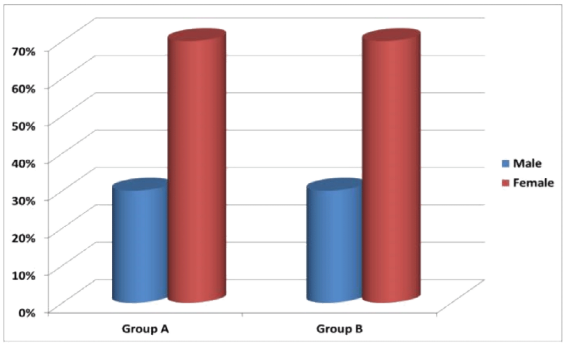

Figure 5. The percentage of female and male patients in both groups

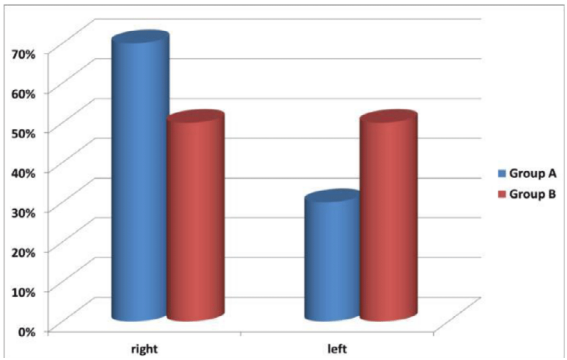

Figure 6. The percentage of the affected right and left hands in both groups.

transposed as a book leaf to cover the median nerve. The free border of the muscle then was sutured to the radial cut remnant of the TCL and the skin was closed primary over it [Figure 1].

A postoperative splint had been applied for about 10 days after surgery. The wrist had been kept in the neutral position within the splint. We kept the fingers free to allow immediate postoperative mobility within the splint. Immediately after the splint was discontinued, the patient was encouraged to start wrist active range of motion exercises to minimize cicatricial tethering helping restoration of the gliding surface of the median nerve. Sutures were removed 10-14 days after the operation.

All patients underwent postoperative subjective and objective evaluation after the operation including the subsidence of the preoperative symptoms [pain, tingling, and numbness] and signs [Tinel's and Phalen's tests] and a new nerve conduction study [motor and sensory nerve latency] 3 months after the surgery. Then we compared these results with the preoperative data of each patient. Also, any complications in the postoperative period were encountered. The mean follow up period was 9.2 months in the first group and 8.4 months in the second group.

Statistical package for the social sciences [SPSS] version 15 was used for the statistical analysis. Qualitative data were presented as number and percent. Comparison between the groups was done by Chi-Square test. Quantitative data were presented as mean ± SD. Paired t-test was used for comparison within the groups. Student t-test was used to compare between both groups. P value <0.05 was considered to be statistically significant.

Results

In this study we found that the number of recurrences before performing the procedure was one in 15 patients, two in 4 patients and three times in one patient [table 1]. The percentage of male and female patients, and the affected right and left hands are shown in figures 5 and 6 respectively.

Table 1. Number of recurrences in each individual group and the P-value for it.

	Group A [n = 10]		Group B [n = 10]		P
	No	%	No	%	
No. of recurrences					
One	7	70%	8	80%	0.356
Two	3	30%	1	10%	
Three	0	0%	1	10%	

In Group A:-

The main CTS symptoms [pain, tingling, and numbness] were present in all patients preoperatively and improved in 80% of patients postoperatively. All patients had a positive Tinel's sign and a positive Phalen's sign preoperatively. After the surgery, Tinel's and Phalen's signs disappeared in 8 of our 10 patients. The mean preoperative and postoperative motor and sensory nerve latencies and the P value for them are shown in table 2.

Table 2. P-value of independent samples test for age, time elapsed since the last operation, and follow-up period.

	Group A[mean]	Group B[mean]	P-value
age[years]	40.6	43.7	0.539
time since last operation[months]	8.5	8.3	0.804
follow-up period[months]	9.2	8.4	0.603

In Group B:-

The main CTS symptoms [pain, tingling and numbness] were present in all patients preoperatively and improved in 90% of patients postoperatively. All patients had a positive Tinel's sign and a positive Phalen's sign preoperatively. After the surgery, Tinel's and Phalen's signs disappeared in 9 of our 10 patients. The mean preoperative and postoperative motor and sensory nerve latencies and the P value for them are shown in table 3.

Table 3: The pre and postoperative mean motor nerve latency, sensory nerve latency, change of motor nerve latency, and change of sensory nerve latency in both groups and the P value for them.

	Group A [N=10]	Group B [N=10]	P
Motor nerve latency [pre]	5.40 ± 0.65	5.48 ± 0.76	0.808
Motor nerve latency [post]	4.28 ± 0.85	3.97 ± 0.68	0.381
Change of motor nerve latency	1.13 ± 0.54	1.51 ± 0.33	0.072
Sensory nerve latency [pre]	4.10 ± 0.43	4.23 ± 0.58	0.592
Sensory nerve latency [post]	3.27 ± 0.84	3.05 ± 0.80	0.544
Change of sensory nerve latency	0.83 ± 0.59	1.18 ± 0.48	0.159

When we compared the postoperative mean motor nerve latency of the median nerve of the operated hands in both groups and also the postoperative mean sensory nerve latency in them, the P-value of t-test for them was 0.381 and 0.544 respectively [>0.05] [table 3]. Then we compared the change of motor nerve latency and the change of sensory nerve latency between both groups, the P value of t-test for them was 0.072 and 0.159 respectively [>0.05] [Table 3].

In the first group, we found that 5 patients complained of tender scar postoperatively, one patient of persistent symptoms, and one patient complained of both of them [tender scar plus persistent symptoms]. There were 3 patients who had no any complain postoperatively. While in the second group, we found also 5 patients complaining of tender scar postoperatively, one patient of tender scar plus persistent symptoms, and one patient complained of limitation of abduction of her little finger of the operated hand. Also, there were 3 patients free of complications.

Discussion

Recurrent carpal tunnel syndrome means that there was complete relief of the patient's symptoms for a definite period of time [6 months at least] after the primary CTR surgery. After that period, the same symptoms develop again. Common causes of recurrent CTS include soft tissue adhesions, interstitial scar formation, and epineural fibrosis [5]. Traction neuropathy occurs when the epineurial surface of the median nerve is surrounded by fibrous adhesions. So, the median nerve is irritated by repetitive finger and wrist flexion and extension [6,7]. The fibrous tissue surrounding the median nerve may either compress the nerve externally or spot-weld the nerve to the surrounding structures. Other contributing factors may be improper hemostasis, neglected physiotherapy, and prolonged immobilization [3].

Many surgical techniques to treat the recurrent CTS had been described in the literature. In 1985, Louis et al. had reported the results of their study on 26 cases with true recurrences after simple neurolysis and these results had been disappointing in six [16]. Then in 1992, O'Malley et al. had reported the results of a study on 20 patients of secondary CTR surgery [17]. Nine of them showed incomplete release of the TCL and eleven cases showed true recurrent CTS with fibrosis. Nowadays, most authors agree that coverage of the median nerve must be performed after any type of neurolysis [18].

Coverage of the median nerve can be then done with various means and various types of flaps. Scarring of

the median nerve can be prevented using multiple local pedicled muscle flaps which can cover the nerve. The muscle flaps which can be used for this purpose include the lumbrical muscle, the pronator quadratus muscle, the palmaris brevis muscle [5], and the abductor digiti minimi muscle flap [19].

In 1996, Strickland et al. reported excellent outcome when using the hypothenar fat pad flap in covering the median nerve in cases of recurrent CTS [20]. These satisfying results included 62 hands at an average follow up period of 33 months. A modified hypothenar fat pad flap had been used in 2000 by Mathoulin et al. in 45 cases with recurrent CTS. After an average follow up period of 45 months, the results had been excellent in 49%, good in 45%, average in 4.5%, and failed therapy in only 4.5% of the 45 patients [21]. However, disadvantages of the hypothenar fat pad flap include limited ability in coverage of the nerve both proximally and distally and the difficulty to be wrapped circumferentially around the nerve [18].

Between 2015 and 2016, 20 cases complaining of recurrent carpal tunnel syndrome were included in our study. They were then divided into two groups: group A contained 10 patients where the hypothenar fat pad flap was used to cover the median nerve, and group B contained 10 patients where a local muscle flap was used [abductor digiti minimi muscle in 6 patients and palmaris brevis muscle in 4 patients]. External neurolysis of the median nerve was done in all of our cases.

There are mainly two key intraoperative steps which should be taken into consideration when harvesting any of these flaps. The first is meticulous dissection taking care to avoid injury of the vascular pedicle, and the second is tension free suturing of the flap to the radial remnant of the transverse carpal ligament.

Then, we compared between the two groups using mainly the pre and postoperative results of the motor and sensory nerve latencies of their nerve conduction studies. Also, we documented the presence or absence of the symptoms [pain, tingling, and numbness] and signs [Phalen's and Tinel's signs] of the carpal tunnel syndrome before and after the secondary carpal tunnel surgery in the two groups.

In group A, we found a statistically significant difference between the pre and postoperative sensory nerve latency [P-value 0.002] and the pre and postoperative motor nerve latency [P-value <0.001]. The same occurred in group B with a highly statistically significant difference between also the pre and postoperative sensory nerve latency [P-value <0.001] and the pre and postoperative motor nerve latency [P-value also <0.001] indicating significant relief of nerve compression after the surgery.

Furthermore, we compared between the hypothenar fat pad flap and the local muscle flap. We found that there was no statistically significant difference between the two groups regarding the postoperative sensory nerve latency and postoperative motor nerve latency of the nerve conduction study [P-value 0.544 and 0.381 respectively]. Also, there was no statistically significant difference between both groups when comparing the change of motor nerve latency and the change of sensory nerve latency in each of them [P-value 0.072 and 0.159 respectively]. The importance of this study comes from the lack of similar comparative studies in the literature comparing between different types of the flap coverage of the median nerve in the management of recurrent CTS.

In 2013, Soltani et al. reported that there is a paucity of comparative studies regarding the subject of the recurrent CTS and that almost all the published studies show results of a single technique or few techniques without comparison of efficacy. In this study, a systematic review was done for all articles on the surgical treatment of the persistent and recurrent CTS that had been published from 1946 until 2012. There were no prospective randomized studies available to be included. They reported that flap treatment within secondary CTR surgery had implied to have equal effect regardless the type of flap used and that there is some debate in the literature of plastic surgery regarding the clinical outcomes and vascularity of fascia versus muscle flaps; meanwhile, most recent data show no difference between subtypes of flaps. So, flap interposition regardless of which type [fat, fascia or muscle] had been found to have equal effect on clinical outcome in this study. Finally, they recommended that further randomized controlled trials are needed to confirm their previously mentioned findings [22]. Hence, the importance of this study is that it does not only focus on the efficacy and results of a single technique, but also compares the results of two different techniques or two different types of flap interposition in the management of the recurrent CTS.

The improvement in the clinical symptoms and the NCS could possibly be explained by the meticulous median nerve neurolysis, the improvement of the median nerve

blood supply, and the cushion effect of the flap either the fat or the muscle flap.

In the postoperative follow-up of this study, we found that the tender scar had been the main complain of our patients accounting for half of cases in each group. This tender scar was also present in association with persistence of the preoperative symptoms in one patient in each group. This scar was managed with oral analgesics and topical anti-inflammatory cream [e.g. betamethasone cream twice daily] for two to three weeks postoperatively then the anti-scar measures were started after that for four to six months. The patients were re-assured regarding the tenderness of their scars and that it would disappear with time. It took three to six months for this tenderness to disappear. One patient of the first group complained of persistence of his preoperative symptoms with no any other complication. One of the six patients of the second group who underwent ADM muscle flap complained of limitation of the abduction of his little finger of the operated hand. Three patients in each group were completely free postoperatively with no any complications noticed. No infection, hematoma formation, or wound dehiscence were encountered.

Although our study is a prospective one with a larger sample size in absence of other similar studies, it had some limitations. It missed the assessment of the grip strength [indicator of motor hand function] and the evaluation of the sensitivity of the hand either using the two-point discrimination or the Semmes-Weinstein measurements [indicator of sensory hand function].

Conclusion

Recurrent carpal tunnel syndrome means complete disappearance of symptoms of CTS for at least six months after the primary CTR surgery. The commonest cause is soft tissue adhesions around the median nerve. The treatment includes first release of adhesions around the nerve then its coverage with a vascularized tissue. Many forms of vascularized tissues can be used. Here, we compare between coverage of the median nerve using either the hypothenar fat pad flap or a local muscle flap [ADM muscle or palmaris brevis muscle flap]. We concluded in our study that there is no statistically significant difference between both types of flaps regarding the results of the postoperative nerve conduction studies and subsidence of the symptoms and signs of the patients.

Two different types of flaps were used in this study for coverage of the median nerve. Group A included 10 patients who had median nerve coverage using the hypothenar fat pad flap. A plane was developed using sharp dissection between the hypothenar fat and the overlying skin taking care to preserve some of the subcutaneous fat to preserve the skin viability. When reaching ulnar to the dermal insertion of the palmaris brevis muscle, the plane of dissection was changed to be vertical in a downward direction till reaching the hypothenar muscle group [Figure 2-A]. The fat pad was then elevated off the hypothenar muscles. The fat pad flap was transposed over the median nerve to the radial side of the carpal canal to assess its tension. In 6 patients, no tension was noticed on the flap and accordingly it was sutured over the median nerve to the radial remnant of the previously cut TCL. In the remaining 4 patients, flap tension existed and required additional maneuver to overcome it. In 3 patients, tension subsided after further dissection of the flap off the underlying ulnar leaf of the TCL and hypothenar muscles till it became suspended only on a vascular mesentry arising from the ulnar artery [Figure 2B]. In only one patient, there was still some tension on the flap and we had to ligate a distal perforator to increase its proximal arch of rotation. Skin closure was the final surgical step.

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