Autologous Fat Transfer in Secondary Carpal Tunnel Release

Natalia Ewa Krześniak, MD, PhD
Bartłomiej H. Noszczyk, MD, PhD

Background: Carpal tunnel release is the gold standard for the treatment of median nerve compression disease. Recurrent or persistent symptoms do not occur in most patients, although a small number of them have indicated that such a postoperative condition indeed exists. Some patients undergo repeated treatments. In the majority of the cases, the disease is associated with scarring in the carpal tunnel or even reformation of the carpal ligament. The authors propose the usage of autologous fat grafting during secondary carpal tunnel release to inhibit the scarring process.

Methods: Ten patients with recurrent or persistent symptoms underwent autologous fat grafting at the time of their repeated carpal tunnel release. Fat was harvested from the lower abdomen and grafted into the scarred transverse carpal ligament and surrounding tissues. Each patient underwent pre- and postoperative examinations and completed the carpal tunnel questionnaire (Boston) to evaluate their sensory and motor functions. The patients underwent 1 year of follow-up.

Results: There were 2 main reasons for continued symptoms: a technical mistake resulting in incomplete release (IR) during the first operation and abundant scarring (ABS) in the operated area. The beneficial effects of the interventions were confirmed by a clinical study and by administering the carpal tunnel questionnaire to all patients (functional severity score decreased from 4.38 to 1.88 in IR and 3.62 to 1.48 in ABS group, sensory severity score from 3.26 to 1.7 in IR and 3.04 to 1.48 in ABS group; \( P < 0.05 \)) after 12 months of follow-up.

Conclusion: Our initial observations suggest the possible efficacy of adipose tissue in secondary carpal tunnel release. (Plast Reconstr Surg Glob Open 2015;3:e401; doi: 10.1097/GOX.0000000000000374; Published online 18 May 2015.)

Median nerve compression in carpal tunnel syndrome (CTS) is currently the most common hand neuropathy. The symptoms depend on the advancement of the disease and increase gradually, beginning with paresthesias and pain (especially during the night) and culminating in hypesthesia of the hand accompanied by weakness and a loss of precision and strength.¹ The disease stage is confirmed by electrodiagnostic (electromyography, EMG) evaluation.

Both conservative and surgical treatments are used for the management of CTS. Conservative treatments include wrist splints, corticosteroid injections, and rehabilitation. These conservative approaches...
are effective during the early phase of the disease and sometimes allow for the postponement of surgical interventions. CTS is most successfully treated with operative techniques (endoscopic, mini-invasive, or open). The aim of surgical treatment is nerve decompression by dividing the transverse canal ligament and the distal part of the antebrachial fascia (AF). Consequently, the pressure in the canal is decreased, and the volume of the tunnel space is increased. Under such conditions, the median nerve fibers are able to regenerate.

After surgical treatment, most patients confirm immediate or delayed improvement. In case of advanced disease accompanied by prolonged numbness in the fingers and hand weakness due to substantial thenar muscle atrophy, recovery can be delayed for months or even up to a year. In addition, due to severe nerve damage, only partial regeneration of the fibers may occur. Some patients must accept that neither entire sensory nor motor abilities can be restored. However, even if some functions are irreversibly lost, most patients report positive aspects of the treatment (such as the resolution of night pains and the progressive improvement of manual function).

Although the results of the treatment of CTS are mostly satisfactory, there is a small but significant group of patients who experience persistent or recurrent symptoms even after surgical management. In few cases, a patient may not experience any relief after treatment (persistent symptoms). Usually, patients confirm the partial amelioration of symptoms, for example, the resolution of night pains but with persistent numbness. Practically, recurrence is diagnosed after a period (usually some months) of actual improvement of symptoms.

In patients with prolonged symptoms who have undergone surgery, other reasons for the recurrence or persistence of symptoms that are not related to CTS should also be excluded. It is important to consider that various general disorders can produce similar symptoms.

Because postoperative recovery requires time, we usually observe a decreasing intensity of symptoms. However, the duration of observation required for patients lacking improvement is unclear. No consensus has been reached among authors with regard to this time period, and most patients undergo repeated surgical interventions between 12 and 30 months after the first intervention. Most likely, an observation period of 6–9 months is adequate for further electromyographic examination. A patient who presents clinical symptoms and a confirmed lack of recovery based on electrodiagnostic criteria may be qualified for a secondary revision.

Two main reasons for recurrence or persistence have been hypothesized by some authors, including a technical mistake and/or scarring; however, the pathogenesis of symptom recurrence or persistence remains unclear. Because abundant scarring (ABS) is usually observed in the carpal tunnel, we propose the use of autologous fat transfer (AFT) during secondary revision, which has been motivated by encouraging outcomes achieved with other applications of fat grafting for tissue regeneration, skin quality improvement, and scarring inhibition. This is a pilot study to demonstrate the feasibility and application of AFT during secondary carpal tunnel release (SCTR).

**METHODS**

Between 2010 and the middle of 2013 (3.5 years in total), a total of 1158 endoscopic carpal tunnel release procedures were performed at the Department of Plastic and Reconstructive Surgery of the Prof. W. Orłowski Memorial Hospital.

Ten patients with persistent or recurrent symptoms were included in this study. Three of them were first treated at our department, and 7 were treated at other places. The performance of secondary revision was based on a lack of improvement or the exacerbation of parameters of nerve conduction as revealed by EMG evaluation. Each patient was reviewed using the Boston carpal tunnel questionnaire before and after management. Clinical outcomes were analyzed using Student’s *t* test to determine whether there were any significant differences between the pre- and postoperative values of the questionnaire, and *P* values of less than 0.05 were considered significant. Medical ethics approval was obtained for clinical data analysis performed in this study.

Secondary revision of carpal tunnel was performed as an open procedure. Based on our earlier observation, the majority of cases revealed evidence of scarring process in the primary surgical area. For this reason, we proposed combining AFT with carpal tunnel revision.

The fat was harvested from the lower abdomen after infiltration with standard Klein solution under local anesthesia. Using harvesting cannulas, we obtained approximately 20 mL of fat. The samples were then centrifuged based on the Coleman indication (1200 g for 3 minutes) to separate the blood, water, lidocaine, and ruptured fat cells.

From the beginning of 2012 to August 2013, 10 patients underwent open revision of carpal tunnel with AFT because of recurrent or persistent disease. After standard carpal revision and proper median nerve exposure, the tourniquet was removed, and hemostasis was performed. The fat was transplanted (using...
Coleman cannulas or an 18-G straight needle) into the scarred transverse carpal ligament, the subdermal tissues located around the ligament, the AF, and the surrounding subdermal area. If the nerve was trapped by the thickened epineurium, the epineurium was carefully opened, and fat was injected under it but not into the fibers. At the end of the procedure, a blunt catheter was left in the carpal tunnel, the skin was sutured, and fat was injected directly between the open ends of the transverse ligament (TL) and on the top of the nerve. A small amount of fat was also injected along the canal to prevent scarring. A soft dressing and bandage were applied to the surgical site without splinting (Fig. 1).

RESULTS

A total of ten consecutive patients (aged 55–76 years; average of 63 years; 80% female patients) were included in the group. The mean interval between primary and secondary carpal tunnel release (CTR) was 1 year and 6 months (11–36 months). All patients underwent a minimum of 1-year follow-up after SCTR (mean, 14 months; range, 12–19 months).

The findings that were revealed during the secondary carpal revision are illustrated in Figure 2. The reason for recurrence was determined for 5 of the patients. For 3 of them, a portion of the AF was not cut, which led to compression of the proximal region and the insufficient release of the proximal fascia. For the 2 other patients (*n* = 2), we identified insufficient decompression in the distal palmar region of the TL.

For the 5 remaining cases, the reason for the treatment failure and the lack of improvement after primary CTR was not determined. During exploration, only ABS was observed in the carpal tunnel. We noticed that in these 5 cases, reformation of the transverse carpal ligament occurred. There was no consistently defined region of nerve narrowing detected. However, the nerve structures were surrounded by scar tissue. During the secondary revision operations in these cases, it appeared as though

![Fig. 1. Management of secondary carpal tunnel release with fat transfer. A, Fat harvesting. B, Scars observed during revision. C, Fat ready for injection with a sharp needle. D, Fat deposition left in the carpal tunnel by a blunt catheter after skin suture.](image-url)
the first operation was not actually performed because the structure of the carpal ligament was very tight and fused, as if it had not been previously released. The surgical approaches employed at the other hospitals were unknown, but we expect that they did not differ substantially from our approaches. In our department, both complete TL and AF release are performed.

Scarring was also observed in the patients (n = 5) who underwent incomplete carpal ligament or fascia antebrachial release, but it was less prominent. The structure of the scar tissue in these cases seemed to be weaker, and the scarring entrapped the nerve fibers to a lesser extent.

The secondary revision for all patients was performed using an open approach, and fat was harvested from the lower abdomen and transplanted into the fibers of the TL, AF, carpal canal, and subcutaneous tissue. All of the wounds healed spontaneously without any complications (Figs. 3, 4). The treatment was supplemented with physiotherapy in all cases.

The routine follow-ups performed during the first year after treatment (SCTR with AFT) revealed beneficial effects for each patient (Fig. 3). All of the patients noted the resolution of night pains. In 5 cases, this outcome was achieved immediately, and in 3 cases, improvement was delayed and occurred over 3–6 months. In 2 patients with protracted disease (10–15 years before primary treatment) and persistent numbness of the fingers, only partial improvement was achieved at 1 year after the procedure. Paresthesia persisted in one of the fingers, but symptom resolution was observed in the rest of the hand (carpal and metacarpal areas and other fingers). This was particularly evident in 1 patient with a prolonged history of severe, insulin-dependent diabetes. Different reasons for illness were revealed in 2 patients with persistent postoperative paresthesia, including one who experienced an incomplete release (IR) of the TL (IR group) and another in the scarring group (ABS group). These 2 patients are still in follow-up.

All of the patients reported beneficial effects, resulting from the interventions. The carpal tunnel questionnaire (Boston protocol)\textsuperscript{16} was completed before surgery and at 3, 6, and 12 months postoperatively. The assessment revealed that the sensory severity score and the functional severity score decreased significantly between the preoperative values and those observed at the 12-month postoperative follow-up (Figs. 5, 6). A significant improvement (P < 0.05) based on the results before surgery and at 12 months postoperatively was observed in both the IR and ABS groups. In the IR group, the total sensory severity score decreased significantly from 4.38 to 1.88, and in the ABS group, it decreased from 3.62 to 1.48. Similarly, the functional severity score decreased markedly from 3.26 to 1.7 in the IR group and from 3.04 to 1.8 in the ABS group. There were no significant differences in improvement between the IR and ABS groups.

![Fig. 2. Findings revealed during secondary carpal tunnel revision.](image)

![Fig. 3. Secondary carpal tunnel release with fat grafting; 1 week after the procedure (A) and 1 month after the procedure (B).](image)
DISCUSSION

CTR is the most common hand surgery procedure, and it usually produces quick symptom relief and resolution. A lack of improvement during the postoperative period after CTR should be carefully addressed because these cases of treatment failure may require secondary revision.

Tung and Mackinnon\(^{10}\) have classified postoperative complaints as persistent, recurrent, or new symptoms. This group analyzed the reasons for persistent disease (no signs of immediate recovery or delayed recovery after operative treatment), suggesting that there may be an IR of the transverse carpal ligament or AF. There are several causes of IR. Inadequate visualization due to patient obesity, posttraumatic disorders in the surgical area, or limited experience with endoscopic approaches is the main reason for treatment failure. In addition, cervical arthropathy or multiregional compression disorder in patients with work-related disease should also be considered.\(^{10,12,17}\)

However, recurrent complaints are usually precluded by a postoperative period of complete or partial recovery. The most common reason for recurrent complaints is problems related to postoperative wound healing. Scarring in the retinaculum, in areas that are in direct contact with the nerve (nerve entrapment by scarring), or even reformation of the carpal ligament usually corresponds with symptom recurrence.\(^{10,11}\)

The optimal timing of the secondary operation is still unclear. In the literature, there is no definitive consensus on the ideal period of observation or when reoperation on the carpal canal should be performed. Based on the progressive aspect of the compressive degeneration of the nerve, long-term observation is not beneficial. In our opinion, approximately 6–9 months of observation with EMG confirmation is an adequate approach in this context.

SCTR is a somewhat challenging procedure. During secondary revision, careful exploration of the canal must be conducted because the position of the nerve can be changed. The risk of nerve injury is increased during scar excision or surgical exposure.

In half of our patients, we showed that IR (in the distal or proximal region) was the reason for disease recurrence or persistence. In this group of patients, secondary revision revealed the reason for the persistent or recurrent symptoms. In the second, more questionable group (ABS), the reason for the persistent or recurrent symptoms was undetermined. However, in this group, despite the ABS of the carpal ligament and adjacent structures, substantial changes in the nerve structures were not detected.
To date, many additional techniques for secondary CTS have been proposed. Many surgeons have highlighted the necessity of extended management in such cases. Based on nerve assessment, external epineurolysis, neuroma-in-continuity assessment, neuroma management, and even collagen conduits have been recommended. In cases involving scarring disorders, some methods of covering nerve fibers have been proposed. Tissue interposition flaps such as the radial artery fascial flap, perforator-based radial forearm fascial flap, thenar or hypothenar fat pad flap, and different types of muscular flaps have been developed. Most of these flaps require demanding procedures that warrant the preparation of an extensive range of adjacent tissues.

The positive outcomes associated with AFT containing adipose-derived stem cells have been widely studied during the last 20 years, and the technique modified by Coleman has been shown to be effective and stable. AFT has been proposed for many clinical disorders that require volumetric or reconstructive management.

This is a preliminary report on the possible use of autologous fat grafting in secondary carpal tunnel interventions. The concept of accompanying fat tissue transfer originated as an actual need for an adequate and easy procedure that could be combined with revision. Secondary revision has always been considered a high-risk procedure. In addition to classical management strategies, such as accurate and gentle treatment during surgery, nerve trunk release, nerve fiber visualization, and epineurolysis, if necessary, an antiscarring remedy seems to be beneficial for improved recovery.

Fat tissue is associated with some beneficial effects at the recipient site. The scarring process can be inhibited due to the effects of this tissue on the structures of the TL and AF, for example, it directly leads to their increased elasticity and suppleness. This effect can be observed by the surgeon who performs the AFT. Many beneficial influences of AFT on tissue quality have been documented, including wound healing after radiation, scar regeneration, burn healing, and Dupuytren’s disease (DD) attenuation.

ABS seems to be histologically similar to fibrosis. The process of pathologic fibrosis is observed in contractures of the palmar aponeurosis due to excessive collagen production, which also occur in DD. Local fat tissue deficiency in the affected subdermal area has been observed in both DD and secondary CTS.

Fat tissue transfer reduces pathologic fibrosis and most likely decreases a tendency toward excessive collagen production, similar to DD, as initially described by Khouri et al. This reduction is also observed in patients treated successfully with percutaneous aponeurotomy. The transplanted fat partially replaces the scar tissue. It is concentrated in the created tissue voids and inhibits fibrosis, which prevents symptom recurrence.

The hypothetical regenerative potential of the fat tissue may depend on adipose-derived stem cells, which are present in the tissue. These cells stimulate the regeneration of skin and adjacent tissues. Although the influence of fat tissue on the quality of skin has been studied in experimental models, there have been no studies on the impact of fat tissue on subdermal structures. However, fat is subsequently deposited under the skin, and skin regeneration is induced by this treatment. This beneficial and expected effect is widely used, especially in aesthetic applications. The influence of fat on the subdermis seems to have the opposite effect because collagen production in this region does not change. For this reason, percutaneous aponeurotomy with subdermal fat deposition is effective in patients with DD.

Similar to DD, secondary CTS is observed in some patients who exhibit scarring of the ligament accompanied by skin and subdermis atrophy, which commonly immobilizes all tissue levels. In our opinion, fat cells not only improve the state of the ligament by rearranging the ligament fibers but also improve the adjacent tissues at every stage of the disease, including the carpal ligament, subdermis, and skin. After fat transfer, the elasticity of the carpal ligaments may be increased, and they are restructured. These effects are beneficial for all patients, especially those with a tendency toward ABS.

It is worth considering that secondary release can be associated with improvement in up to 60–70% of patients. The surgical treatment is a basal treatment, and it cannot be substituted, but it does not protect from scar recurrence. The same patient with a scarring tendency can redevelop a scar. The addition of adipose tissue may create a favorable environment for the healing process by providing protection from scarring in a similar manner as the pad flaps proposed earlier. However, fat transfer cannot replace surgery.

Fat tissue deposited in the carpal tunnel directly around the nerve creates a pad for regeneration, and hypothetically, the stem cells from the fat (with their multipotent abilities) may influence or even stimulate nerve fiber regeneration.

The limitation of this pilot study is the small number of patients evaluated. We included 10 patients (3 from our department and 7 who requested a secondary revision after they were initially treated at other hospitals). The problem of recurrence is not very common, although the percentages reported
in the literature have varied from 3% to 20%.\textsuperscript{10,11,13} All secondary revisions have been performed using an open approach combined with fat transfer. This study estimated the feasibility of this type of treatment, in which fat transfer was used as an antiscarring remedy in a small group of patients with a high risk of recurrence.

Most of our patients achieved stable improvement over the observation period. However, long-term follow-up is required to evaluate the rate of recurrence, especially in patients with excessive fibrosis.

**CONCLUSIONS**

In our opinion, carpal tunnel release with fat grafting can be an alternative treatment option for secondary cases. A small amount of fat can be easily obtained from the abdomen or thighs and transplanted into carpal tunnel tissues. The harvesting and grafting procedures only require a few additional minutes. Because of its minimally invasive characteristic, this procedure can easily replace other proposed methods.

This pilot study introduced the possibility of fat grafting during SCTR. However, randomized controlled trials are required to compare the results of different techniques.

*Natalia Eva Krześniak, MD, PhD*

Department of Plastic and Reconstructive Surgery
Centre of Postgraduate Medical Education
Prof. W. Orlowski Memorial Hospital
00-416 Warsaw, Czerniakowska 231, Poland
E-mail: natalia.krzesniak@wp.pl

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