

A Systematic Review of the Outcomes of Digital Sympathectomy for Treatment of Chronic Digital Ischemia

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ABSTRACT. Objective. To determine the effectiveness of digital sympathectomy for treatment of chronic digital ischemia, to provide information on outcomes of this surgical procedure, and to give recommendations for further investigations.

Methods. We conducted a systematic review of English language citations referring to digital sympathectomy published between 1966 and 2002 using Premedline and Medline.

Results. Multiple differences in surgical techniques, causes of digital ischemia, and outcome measurements among studies made comparisons of surgical outcomes difficult. We found that 14% of all patients required amputation and 18% of patients had ulcer recurrence. Some type of postoperative complication was reported in 37% of patients with systemic sclerosis.

Conclusion. To best determine the effectiveness of this surgical procedure, we recommend that future studies are prospective, to include standardized pre- and postoperative measurements, stratify the study outcomes by diagnosis and disease duration, and have consistent postoperative followup intervals. (J Rheumatol 2003;30:1788–92)

Key Indexing Terms:

SYMPATHECTOMY
HAND SURGERY

SYSTEMATIC REVIEW

ISCHEMIA
MICROSURGERY

Flatt¹ first introduced the surgical concept of digital artery sympathectomy in 1980 as a treatment for chronic digital ischemia due to frostbite, trauma, and Raynaud's phenomenon (RP). Before that time, cervical sympathectomy was used as a treatment for digital ischemia, but longterm results have been discouraging². The premise for digital, as opposed to cervical, sympathectomy is that the more distal the surgery to interrupt the sympathetic fibers, the more effective the results. It remains unknown whether digital ischemia is due to pure sympathetic overactivity resulting in vasoconstriction of the digital arteries or whether secondary conditions such as systemic sclerosis (SSc) constrict the digital arteries³⁻⁵. During sympathectomy, the adventitia of the proper and common digital arteries is excised, removing sympathetic fibers contained in the adventitia and most likely, the media^{1,6}. The aim is to increase vessel dilation either by interrupting the sympathetic output to the digital arteries⁷, or by removing the constrictive cuff of periadventitial fibrosis surrounding the arteries⁸.

Several reports⁸⁻¹⁰ have indicated that although the

results are initially favorable in patients with connective tissue disorders, digital sympathectomy may only lead to temporary alleviation of symptoms because of the progressive nature of these diseases. Reisman⁷ reported delayed wound healing in patients with SSc following digital sympathectomy. O'Brien, *et al*¹¹ reported recurrence of mild superficial ulceration in 4 out of 13 patients with SSc or RP.

We systematically reviewed the existing literature in order to synthesize all available data and to determine the effectiveness of digital sympathectomy for chronic digital ischemia. Our objectives were to provide information on outcomes following this surgical procedure and to give recommendations for further investigations.

MATERIALS AND METHODS

We conducted a literature search using Premedline and Medline to identify all English language citations for original research studies related to digital sympathectomy in humans published between 1966 and 2002. The following key words were applied during the search: "sympathectomy," "microarteriolytic," or "adventitial stripping." "Finger" or "digit" were also combined in a search with "scleroderma, circumscribed," "scleroderma, systemic," or "Raynaud's." Bibliographies of articles were examined to obtain articles that were not previously identified.

Metaanalysis is a quantitative method that combines and summarizes the results from multiple studies pertaining to a particular topic¹². While metaanalysis was an initial consideration, a review of the literature on the digital sympathectomy procedure revealed that the majority of studies lacked a comparative control group, making it unfeasible to quantitatively compare sympathectomy to another or to no procedure. Instead, a systematic review of the published research on digital sympathectomy was conducted.

Study criteria. Because it has been shown that results from cervical sympa-

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theectomy are disappointing², only papers containing data on sympathectomy distal to the elbow were included. Case studies, abstracts and/or data included in a letter to the editor were excluded¹³⁻²⁰.

Data abstraction. The data were abstracted from the included papers by an investigator (SVK) who has training in clinical epidemiology. Papers were reviewed by masking the author names and journal titles and assigning each paper an identification number. Identical data abstraction sheets were used to collect the data. It was often difficult to determine the type of study from the information provided. The decision was made not to make any inferences about the studies; if information was not specifically stated in the papers, it was listed as NA (not available) in the tables.

RESULTS

Sixteen studies met our inclusion criteria^{1,6-11,21-29}. Selected papers are described in Table 1. The reviewed studies were published between 1980 and 2001. Nine of the studies did not indicate the type of study design used, 2 were prospective, 4 were retrospective, and one used a combination of prospective and retrospective data. Causes of digital ischemia from the patients in 15 studies (excluding one paper that did not specify the number of study patients) included SSc [n = 65 (diffuse, limited, or type not specified)], RP [n = 8 (primary or type not specified)], trauma/traumatic amputation (n = 10), frostbite (n = 3),

undifferentiated rheumatic disorders (n = 3), atherosclerosis (n = 2), discoid lupus (n = 1), mixed connective tissue disease (n = 1), systemic lupus erythematosus (n = 1), and unknown/unspecified diagnoses (n = 60). Excluding the studies that did not provide data on the number of digits, sympathectomy was performed on a total of 251 digits. The average time to followup after surgery ranged from 0.5 to 4.7 years. The shortest followup in all studies was one month and the longest was 17 years.

Data on amputations were reported in 7 of the included studies^{6,21,23,24,26,28,29}. These amputations were either performed at the time of sympathectomy or postoperatively. Of these 7 studies, 7 patients (14 digits) out of a total of 49 (14%) required amputation (including one study²³ that did not report the number of digits amputated and another study²⁹ that reported the number of digits amputated but not the number of patients). Reasons for amputation included preoperative distal necrosis (n = 3 patients), postoperative recurrence of vascular insufficiency (n = 1), postoperative infection due to splinter entering finger (n = 1), preoperative ulcers with exposed bone or deep infection (n = NA), and unspecified reasons for amputation (n = 2). Table 2 shows

Table 1. Demographics of patients undergoing digital palmar sympathectomy.

Study	Study Design	Sex, n	Mean Age, yrs (range)	Smokers, n	Cause of Digital Ischemia, n	Total Patients, n	Total Hands, n	Total Digits, n	Mean Followup Time, yrs (range)
Egloff ²⁷	NA	M, 13 F, 0	44 (25-67)	1 smoker; 12 NA	Primary RP, 4; Trauma, 7 Traumatic amputation,*2	13	13	18	0.7 (0.3-1.2)
El-Gammal ²¹	NA	M, 1 F, 2	39 (17-62)	NA NA	Limited SSc, 1; RP (uns.), 1 Trauma, 1	3	4	11	0.9 (0.3-1.3)
Flatt ¹	NA	M, 4 F, 4	37 (22-56)	NA NA	Frostbite, 3; Trauma, 2 RP (uns.), 1; SLE, 1; SSc (uns.), 1	8	9	17	4.7 (1-17)
Jones ²⁶	Pros	NA	NA	NA	SSc (uns.), 5	5	NA	NA	NA
Jones ⁸	Pros and retro	NA	NA	NA	NA	7	NA	NA	NA
Koman ²⁸	NA	M, 0 F, 6	40 (32-45)	NA	Discoid lupus, 1; SSc (uns.), 5	6	7	7	0.5 (range NA)
McCall ²⁴	Retro	M, 2 F, 5	52 (38-71)	2 smokers; 1 ex-smoker; 2 non-smokers; 2 NA	Atherosclerosis, 2 Primary RP, 1; SSc (uns.), 4	7	NA	23	2 (1 mo-6.3 yrs)
Melone ¹⁰	NA	NA	NA	NA	SSc (uns.), NA	NA	NA	10	NA (1-15)
O'Brien ¹¹	NA	M, 5 F, 8	54 (22-73)	NA NA	Mixed connective tissue disease, 1 Primary RP, 1; SSc (uns.), 11	13	17	52	NA (1-5)
Reisman ⁷	NA	NA	NA	NA	NA	42	NA	51	2.2 (1-NA)
Stratton ²³	Retro	NA	NA	NA	SSc (uns.), 13	13	NA	NA	1.6 (range NA)
Tham ²⁵	NA	M, 0	39	NA	Limited SSc, 4; SSc (uns.), 2	7	10	22	1.9 (1-3)
Tomaino ²⁹	Retro	F, 7 M, 1 F, 5	28-60 45 (31-57)	3 before surgery; 2 quit after surgery; 1 NA	Unknown, 1 SSc (uns.) 6	6	8	NA	2.5 (1.5-3.3)
Ward ⁹	Pros	NA	42 (27-61)	NA	SSc (uns.), 7	7	9	9	3.9 (2.2-5.3)
Wilgis ²²	NA	NA	NA	NA	NA	10	NA	18	NA (NA-4)
Yee ⁶	Retro	M, 0 F, 9	39 (20-53)	1 ex-smoker; 8 NA	Limited SSc, 4; Diffuse SSc, 2 Undifferentiated rheumatic disorders, 3	9	10	13	NA (0.8-3.9)

Pros: Prospective; Retro: Retrospective; NA: not available; Uns: type not specified; * Extent of amputation not specified.

the combined data from 6 of these studies (excluding one that did not report the number of patients having amputations). Five out of 34 patients (15%) with some form of SSc required amputation as did one out of 2 atherosclerosis patients (50%). The other patients in these 6 studies who did not require amputation included those with undifferentiated rheumatic disorders (n = 3), RP (n = 2), discoid lupus (n = 1), and digital ischemia due to trauma (n = 1). Time between surgery and amputation was stated in only 2 studies^{21,24}: one and 7 months.

When data on ulcer healing were available, the time to healing after surgery ranged from 2 weeks to 7 months. Of 8 studies where data could be ascertained^{1,6,9,11,21,24,25,29} (excluding 5 patients from one study¹ who did not have any data), 51 patients had preoperative ulcers and ulcers recurred/had incomplete healing in 9 of these patients (18%) (Table 3). Data from 4 papers^{6,21,24,29} reporting patients with amputations were verified to confirm that ulcers were not counted as healed due to a digital amputation. All of the 8 studies reported ulcer healing or recurrence for each diagnosis. In these studies, ulcers recurred/had incomplete healing in 6 out of 38 patients with some form of SSc (16%), 2 out of 3 patients with some form of RP (67%), and in the only patient with mixed connective tissue disease. Complete ulcer healing following sympathectomy was reported for patients with undifferentiated rheumatic disorders (n = 3),

atherosclerosis (n = 2), frostbite (n = 2), digital ischemia due to trauma (n = 1), and an unknown disorder (n = 1). Time to ulcer recurrence was reported in 2 papers^{9,24} for 4 patients and occurred at 6 months, 8 months, 11 months, and 2 years after surgery.

Data on complications, excluding amputations, were unreported in 6 studies^{1,8,10,11,26,28}. Excluding one study⁷ that did not indicate the number of patients affected with a particular complication and another study²² that reported no complications but did not provide patient diagnoses, data for each diagnosis were obtained from the remaining 8 studies. The combined data from these studies revealed that there were 3 complications (hypoesthesia of pulp, delayed healing of surgical incision, and persistent hand edema) for 18 patients with some type of RP (17%). There were 16 complications in patients with SSc (5 delayed wound healing, 2 fingernail detachments, 2 minor wound problems, 2 spontaneous losses of distal tip, 2 stiffness of the proximal interphalangeal joint, one reflex sympathetic dystrophy, one recurrent infection, and one skin thickening around the scar) out of 43 patients with some form of this disease (37%). There were no complications reported in patients with atherosclerosis (n = 2), digital ischemia due to trauma (n = 1), and an unknown diagnosis (n = 1).

DISCUSSION

As first described in 1862, RP is the occurrence of episodic attacks of well-demarcated ischemia of the digits on exposure to cold and sometimes emotional stimuli³⁰. Only one or 2 digits are often first affected, but all digits may become involved with time. A diagnosis of primary RP is made when no underlying disease is detected after 2 years of followup³¹. Secondary RP is a clinical entity that is due to an underlying disease. Associated conditions include arterial diseases, immunological and connective tissue diseases, hematologic abnormalities, thoracic outlet syndrome, occupational causes, drugs and toxins, neurological diseases, and other miscellaneous disorders³⁰. Primary RP is most common in young females 11 to 45 years of age. The female to male ratio is 4:1, with no racial predisposition³². There is

Table 2. Results of patients requiring amputation.

Cause of Digital Ischemia	Total Patients*, n	Patients Requiring Amputation, n
Total	43	6
Systemic sclerosis	34	5
Atherosclerosis	2	1
Undifferentiated rheumatic disorders	3	0
Raynaud's phenomenon	2	0
Discoid lupus	1	0
Trauma	1	0

* Results reflect combined data from 6 studies^{6,21,23,24,26,28} that reported amputation data for each diagnosis.

Table 3. Results of patients having digital ulcers.

Cause of Digital Ischemia	Patients with Preoperative Ulcers*, n	Patients with Postoperative Ulcers, n
Total	51	9
Systemic sclerosis	38	6
Raynaud's phenomenon	3	2
Mixed connective tissue disease	1	1
Undifferentiated rheumatic disorders	3	0
Atherosclerosis	2	0
Frostbite	2	0
Trauma	1	0
Unknown	1	0

* Results reflect combined data from 8 studies^{1,6,9,11,21,24,25,29} that reported digital ulcer data for each diagnosis.

an increasing intensity of associated symptoms and signs related to the severity of the RP, including swelling and stiffness of the fingers, tapering of the distal phalanges, contractures, ulcers, and eventually gangrene³⁰. RP is the initial complaint in roughly 70% of patients with SSc. SSc is characterized by thickening and fibrosis of the skin (scleroderma) and involvement of the internal organs. It is divided into 2 forms, the diffuse variant and the limited variant. Patients with diffuse SSc have a rapid progression of skin thickening on the face, trunk, and extremities. The limited variant is also termed CREST (calcinosis, RP, esophageal dysfunction, sclerodactyly, and telangiectasia) and involves a slower progression of skin thickening on the face, neck, and sites distal to the elbow and knee³³.

Patients with digital ischemia must undergo a thorough evaluation and attempt conventional methods of treatment such as smoking cessation, cold avoidance, biofeedback techniques, and pharmaceutical therapy before undergoing surgical treatment^{9,22,34}. Medical management includes the coordination of both rheumatologists and hand surgeons. Surgical treatments for digital ulcers have incorporated several options, including skin grafts. However, a normal skin graft placed on a sclerodermatous recipient bed becomes sclerodermatous itself³⁵. Results of cervical sympathectomy have also been disappointing. Pick² argued that [other] pathways, especially the intermediary ganglia, are often allowed to remain untouched during [cervical] sympathectomy and later play an important role in residual sympathetic activity. Surgical treatment has also included fingertip amputation; however, this can result in significant losses in terms of esthetic outcome and function.

We were unable to combine the reviewed studies into a metaanalysis because of the differences in study design and data collection. First, the studies would need to provide both case and control data. Therefore, cases would be patients who underwent sympathectomy, while controls would be patients who underwent another form of or no treatment. The selection of cases is a vital aspect of a study. As stated, RP is most common in young females. If the case subjects do not reflect the population of individuals with RP, the question of whether participants were selectively enrolled should be raised. Additionally, the majority of studies (n = 12) did not include information on the number of patients who smoked preoperatively: a very important concept in digital ischemia. Reisman⁷ illustrated with pulse volume recordings that one cigarette significantly reduces digital blood volume. If patients who smoke are selected as study participants, this may also skew the reported outcomes in comparison to a study with patients who do not smoke.

As shown in Table 1, there was a large discrepancy among and within studies regarding length of followup after surgery. The shortest followup interval was one month and the longest was 17 years. Short term results of digital sympathectomy can vary from those observed in the

longterm. For example, in the study by McCall, *et al*²⁴, followup after surgery ranged from one month to 6.3 years, with an average of 2 years. The average time to ulcer healing was reported as 14 weeks, but one patient had a recurrent ulcer 8 months after surgery and another had a recurrent ulcer 2 years after surgery. Thus, a shorter followup may not reveal the recurrence of such an outcome. Further, a longer followup may show that some patients require a repeat procedure or that certain diagnoses have improved outcomes over others. One of the patients in the study by McCall, *et al*²⁴ was a repeat sympathectomy. This same patient had undergone several sympathectomies, most likely due to a release of constricting scar tissue around the digital arteries⁸. Several papers⁸⁻¹⁰ have indicated that although the results are initially favorable in patients with connective tissue disorders, digital sympathectomy may only lead to temporary alleviation of symptoms because of the progressive nature of these diseases. Reisman⁷ reported delayed wound healing in patients with SSc. Similarly, Yee, *et al*⁶ found that 2 of their patients with diffuse SSc had slower postoperative change. O'Brien, *et al*¹¹ reported recurrence of mild superficial ulceration in 4 patients out of 13 with SSc or RP. On the other hand, El-Gammal, *et al*²¹ described partial pain relief in patients with digital ischemia due to trauma, but complete relief in a patient with limited SSc and another patient with RP. These results indicate that the combination of patients with differing diagnoses into one sample will affect the surgical outcomes. However, stratifying the patients by diagnosis, as shown in Tables 2 and 3, results in small sample sizes, limiting the possibilities for statistical analysis.

Several factors need to be taken into consideration before study initiation in order to fully understand the longterm results of this surgical procedure. First, the study must be prospective. This will allow for the collection of preoperative measurements that can be compared with those taken postoperatively in the same patient. It will also eliminate recall bias, which can occur in retrospective studies when patients attempt to recall preoperative aspects of their disease. The limitations of collecting prospective data are the time and money needed to collect sufficient data. Second, the study must either include patients with one diagnosis or else enlist a large sample size to allow for the stratification of patients by diagnosis and disease duration. This will allow for the analysis of outcomes by diagnosis. Third, the case subjects should reflect those afflicted with a certain diagnosis in the general population in terms of characteristics such as sex and age. Further, study subjects should be similar to one another in terms of disease severity and responses to prior treatment. A multicenter study with consecutively enrolled patients would allow for a large sample size with increased generalizability of the collected outcomes. It would also be ideal to randomize patients into different treatment groups to minimize confounding vari-

ables. However, a multicenter study would require the standardization of treatment across sites and a randomized study could be biased by the inclusion of patients who are willing to be randomized to treatment and thus limit the generalizability of the results. Fourth, standardized outcomes measurements should be used for collection of pre- and postoperative data. A self-administered questionnaire would allow patients to subjectively assess their improvement while providing a standard measurement scale. Objective tests, such as cold stress with digital temperature recordings, must also be assessed pre- and postoperatively. Fifth, patients must be postoperatively assessed at consistent time intervals. This would allow complications to be recorded as they occur postoperatively, and also allow for the comparison of short and longterm outcomes.

Although the results of digital sympathectomy appear to be encouraging, there are some discrepancies in the published literature. Patients with connective tissue disorders may not obtain results that are as favorable as patients with other diagnoses, they may take longer to obtain favorable results, and/or they may require repeat procedures. We found that the majority of patients undergoing digital sympathectomy had SSc; however, 15% of these patients required digital amputation, 16% had a recurrence/incomplete healing of digital ulcers, and 37% had a postoperative complication. Treating physicians may wish to reserve the use of digital sympathectomy for patients with severe digital ischemia who do not respond to medical treatment³⁶. Patients should also be made aware that this surgical procedure might only result in temporary alleviation of symptoms, and surgical outcomes could vary by diagnosis.

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