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Surgical Causes of Recurrent Carpal Tunnel Syndrome

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Abstract

The aim of this research is to characterize the most common causes of recurrent carpal tunnel syndrome. Cases that were included in this study subjected to a detailed history and examination. The diagnosis was confirmed by electrophysiological studies and intraoperative findings. This study demonstrates that, all patients were found to have fibrosis surrounding the median nerve, which was attached to the radial leaf of the transverse carpal ligament, except one patient whose median nerve was found to have an adhesion to the subcutaneous tissue and 6% of the cases were found to have the incomplete release of the flexor retinaculum.

Keywords: carpal tunnel, recurrent, surgical causes.

الملخص.

تهدف هذه الورقة إلي ايجاد أشهر الأسباب المسببة للرجوع المرضي لمرض انسداد العصب الوسطي بالرسغ حيث خضعت كل الحالات في هذه الدراسة إلى الفحص الطبي الدقيق و تم تأكيد التشخيص عن طريق جهاز اختبار التوصيل الكهربي للأعصاب الطرفية, بالإضافة إلى التقييم الموضعي أثناء إجراء العملية الجراحية المعادة. توضح هذه الدراسة أنه، وجد أن جميع المرضى يعانون من تليف محيطي بالعصب الوسيط، والذي تم ربطه بالورقة الشعاعية لرباط الرسغ المستعرض، باستثناء مريض واحد وجد أن عصبته الوسطى لها الالتصاق بالنسيج تحت الجلد. ووجد أن 6 % من الحالات لديها عدم اكتمال الافراج عن المثنية.

الكلمات المفتاحية: انسداد العصب الوسطي – اعادة التدخل الجراحي – الأسباب الجراحية لعودة المرض

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1. Introduction

Carpal tunnel syndrome is the commonest peripheral entrapment neuropathy and a frequent reason behind disability within the upper extremity (Wilson and Sevier 2003). Clinical symptoms including paresthesias or pain, numbness and tingling altogether or a mix of the thumb, index, middle and ring fingers, and weakness or atrophy of the thenar muscles, and physical findings like the Tinel sign and Phalen test, the hand diagram, the grip and pinch strength tests are suggestive of the syndrome [Armstrong and Villalobos 1997, Barun et al 2002, Demopulos and Urbaniak 1996, Kerwin et al 1996, Levine et al 1993, McDonald and Lourie 2005, Wilson and Sevier 2003).

To date, no recognized consistent nonoperative treatment has been documented for carpal tunnel syndrome management; the treatment of choice to predictably relieve symptoms, and also the commonest and fashionable procedure performed in current practice is that the decompression of the median nerve by open release of the transverse carpal ligament (McDonald and Lourie 2005, Learmonth 1933, Steinberg 2002, Wilson and Sevier 2003, Bilasy et al 2012). once the surgery is indicated, it's vital to think about that significant complications might occur. The clinical symptoms which will result in following these complications are also more severe and distressing than the patient's original complaints.

The purpose of this study was to present a variety of complications following carpal tunnel surgery and to debate however they will have occurred and the way they will be prevented.

2. Literature Review

First delineate by Sir James Paget in 1865, Carpal Tunnel Syndrome is the most common example of a nerve compression disorder, attributed to continual or sustained activities that cause partial or complete loss of sensory, motor, and/or autonomic median nerve function, due to pressure against the nerve. alternative terms used to explain this disorder include: writer's cramp, ape hand, occupational neuritis, partial thenar atrophy, and median neuritis. The development of carpal tunnel syndrome inside the industrial community has been recognized and monitored for a few time. though slight, compared with manual

handling injuries, the problem accumulated significantly throughout the 1980's (Green and Briggs 1989) and currently represents a vital proportion of all worker's compensation claims (Brogmus and Marko 1990). many theories to substantiate this upward trend have been recommended, together with symptomatic reporting due to accumulated public awareness of its work-relatedness (Snook 1990).

Decompression of the median nerve by carpal tunnel release (CTR) was 1st delineate within the English literature in the half of the last century (Learmonth 1993, Palmer and Toivonen 1999, Phalen 1970, Phalen 1981, Ibrahim et al 2012) and has become one amongst the foremost common and rewarding operations performed on the hand (Gelberman et al 1988, Gilbert et al 1988). Despite its success, complications and treatment failures are shown to occur in three to one hundred and ninetieth in giant series, requiring re-exploration in up to twelve-tone system for a range of causes (Bande et al 1994, Botte et al 1996, Concannon et al 2000, Langloh and Linscheid 1972, Murphy et al 1994, Wulle 1987, Beck et al 2012).

3. Methodology

The study carried out on 20 patients, for the period of 2 years. all patients subjected preoperatively to detailed history and complete physical examinations and neurological evaluation. The diagnosis was confirmed by electrophysiological studies. Intraoperative evaluation is done through a 1-Minimal skin incision. 2-Good exposure of median nerve. 3- Evaluation of the causes of the compromised median nerve.

4. Results

The average age of the 20 patients at reoperation was 48 years (range 43–61 years), 80% were females, The average interval between the original carpal tunnel release and re-operation was 35 months (range 5–82 months). Twenty-five of 16 procedures were on the right side and four were on the left side. All patients had a positive Tinel sign preoperatively. At reoperation, all patients were found to have fibrosis surrounding the median nerve, which was attached to the radial leaf of the transverse carpal ligament, except one patient whose median nerve was found to have an adhesion to the subcutaneous tissue. 12 cases were found to have the incomplete

release of the flexor retinaculum. After surgery, the Tinel sign disappeared in 18 of 20 patients, see figure1.

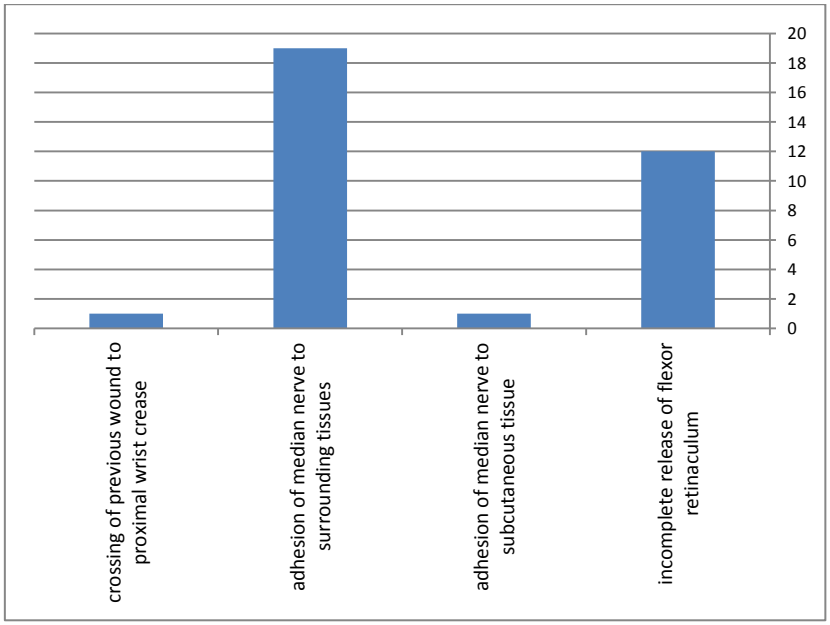


Figure 1: Shows the number of patients relative to the cause of recurrent CTS

5- Discussion

The release of the transverse carpal ligament (TCL) has become the foremost usually performed peripheral nerve operation. Since surgical decompression of the TCL was 1st performed by Learmonth in 1933. several authors have reported a high success rate performing the procedure in many large series of patients (Ariyan and Watson 1977, Cseuz et al 1966, Doyle and Carroll 1968, Gainer and Nugent 1977, Hybbinette and Mannerfelt 1975, Langloh and Linschied 1972, Phalen 1972, Semple and Cargill 1969). Concomitant with the magnified volume of carpal tunnel releases (CTRs), complications became more prevalent. MacDonald, et al. 1978 reported thirty-four complications in 186 patients undergoing operations for carpal tunnel syndrome (CTS). With the arrival of examination CTR (ECTR), the potential for neurovascular and connective tissue injuries has increased, particularly once the operating surgeon performing the procedure is at the start of the educational curve (Rowland and Kleinert 1994). Moreover, the practice of the many academic hand surgeons includes a lot of patients managed for complications of CTR than patients presenting with the initial symptoms of the syndrome (Urbaniak and Desai 1996). based on a 1987 survey of members of the American Society of Hand, this expertise is

typical for several hand surgeons. The survey revealed that seventieth of the 467 respondents performed one to 5 reoperations annually for CTS and Sixteen Personality Factor Questionnaire performed over six reoperations each year (Duncan et al 1987). though few surgical procedures are related to such low morbidity rates, complications from CTR surgery will still be quite disabling to the patient.

Most surgical complications in OCTR surgery result from inadequate or not suitably placed skin incisions. many studies cite incomplete sectioning of the TCL as the commonest complication in OCTR.(Langloh and Linscheid 1972, MacDonald, et al. 1978). MacDonald et al 1978 reported twelve cases of incomplete release of the ligament, constituting thirty-fifth of the overall thirty-four complications found in 186 patients. (Langloh and Linscheid 1972) found incomplete resection of the TCL in twenty-one of thirty-four wrists investigated for persistent symptoms following surgery. Most of the twenty-one partially intact ligaments remained in continuity distally, presumably ensuing from an effort to avoid the superficial palmar arch and therefore the digital nerves. different authors have stressed the importance of releasing the distal forearm connective tissue a few centimeters proximal to the wrist joint crease (Eversmann 1986).

Injury to the palmar cutaneous branch (PCB) of the median nerve is maybe the second most typically cited complication in OCTR surgery (Langloh and Linscheid 1972, Louis et al 1985, McDonald and Lichtuman 1987). Transaction of the nerve with subsequent neuroma formation was recognized in 1972 by Carroll and green (Carroll and Green 1972). once transaction of the PCB with subsequent neuroma formation happens, the 2 recommended treatment choices are to sever the PCB at its origin from the median nerve (Louis et al 1985, Carroll and Green 1972), or to bury the neuroma within the forearm muscles (Urbaniak and Desai 1996). (Martin, et al. 1996) conducted a cadaveric study of the cutaneous innervation of the palm in response to the continuing incidence of painful incisions following OCTR; presumptively the pain was caused by injury to cutaneous nerves with subsequent neuroma formation. They demonstrated that such an incision focused on the axis of the finger resulted in injury to ulnar-based cutaneous nerves in sixteen of twenty-five cadavers and injury to median-based cutaneous nerves in 3 of twenty-five cadavers. Thus, even if an incision based on the axis of the finger could reduce the incidence of palmer cutaneous nerve injury, there's no true "internervous plane" that may fully

avoid all cutaneous palmer branches, whether or not of median or ulnar origin. The findings of Martin, et al., intimate that shorter incisions with the subcutaneous release of the ligament under direct vision or ECTR could also be the only ways of decreasing incision pain from neuromas of cutaneous nerves.

Besides injury to the cutaneous branches of the ulnar nerve, alternative reported ulnar nerve injuries embrace laceration of the nerve in Guyon's canal (Favero and Gropper 1987), transaction of the deep motor branch of the ulnar nerve simply distal to the hook of the hamate within the midpalmar area (Terrono et al 1993), and division of the sensory ramus communicans between the ulnar and median nerves (May and Rosen 1981). The ulnar nerve and artery lie radial to the hook of the hamate and palmar to the ulnar side of the TCL in 15% of people (Urbaniak and Desai 1996), that predisposes them to injury throughout the accidental release of Guyon's canal.

Injuries to the superficial palmar arch (McDonald et al 1978), the ramus communicans between the ulnar and median nerves (May and Rosen 1981), and also the common digital nerve to the adjacent long and ring fingers (Semple and Cargill 1969), have all been reported. Their anatomical proximity to the distal edge of the flexor retinaculum is represented very well within the surgical anatomy section of the paper by Friedman during this issue.

Severance of the thenar motor branch (TMB) of the median nerve ends up in thenar atrophy and loss of opposition. Lilly and Magnell36] reported good results in delayed repair, as late as fourteen months, following initially unrecognized TMB injuries. (Poisel 1974 and Lanz 1977) represented many anatomical variants that are significantly vulnerable to injury. during a study of one hundred cadavers, Poisel found that the TMB becomes recurrent and exits from the median nerve distal to the TCL in forty-sixth of cases. He documented an early ramification of the TMB underneath the ligament in thirty-first of cases and through the ligament in twenty third. The Trans ligamentous variant is maybe additional vulnerable because the transaction of the radial aspect of the ligament will turn out TMB injury. Lanz 1977 drawn the median nerve anatomy in 246 hands explored at operation and reported further anatomical variations which will incline to injury, as well as accessory branches of the median nerve at the distal carpal tunnel and origination of the TMB from the ulnar aspect of the median nerve.

Long-term persistent pain could be a major determinant of the success or failure of the OCTR. The complication of long persistent pain might arise from any of the subsequent causes: hypertrophic skin scarring, intra- and perineural scarring, adherence of the nerve to the skin, subcutaneous tender nerve secondary to superficial position, adhesions between flexor tendons and therefore the median nerve, pillar pain at the thenar and hypothenar eminences, and reflex sympathetic dystrophy (RSD).

Hypertrophic scars are typically the results of an incision that transverses the flexion crease at a right angle. If a painful hypertrophic scar should occur despite all tries at prevention, scar revision should be performed. though the skin of the palmar aspect of the wrist is thin and immobile, a Z-plasty after scar revision is sometimes attainable and is the best remedy.

Intra- and perineural scarring generally produces dysesthesias, pain, and hypersensitivity. Neurolysis is rarely a successful remedy and might probably produce additional scarring furthermore as direct mechanical injury to nerve fascicles throughout intensive dissection. In fact, internal neurolysis at the initial CTR procedure has never demonstrated any benefit over CTR without internal neurolysis; (Gelberman et al 1987, Mackinnon et al 1991) thus, most hand surgeons would agree that internal neurolysis at the initial surgery is rarely indicated. proper haemostasis is vital to prevent perineural scarring. If intra- and perineural scarring should develop despite the surgeon's best efforts to prevent it, the hypersensitivity and dysesthesias might respond to coverage of the nerve with a fat graft or abductor flap (Urbaniak and Desai 1996).

Superficial position of the median nerve and adherence of the nerve to the skin are sometimes consequences of an improper skin incision directly over the nerve, instead of toward the ulna. Splinting the wrist joint in a very slightly dorsiflexed position for the first three to five postoperative days might reduce the probability of superficial nerve position. 3 common ways of insulating the nerve from the skin surface include rotation of a hypothenar fat-pad flap; rotation of local muscle pedicle flaps, like the pronator quadratus and abductor digiti minimi; and Z-plasty with underlying temporary silicone textile to stop scar adherence(Urbaniak and Desai 1996). Tendon adhesions might result from poor haemostasis throughout standard OCTR surgery or from hemorrhage related to tenosynovectomy. resection of the

synovial membrane is sometimes indicated only in cases of very large synovium, like those related to arthritis, due to the propensity of tenosynovectomy to cause bleeding and scar formation with later adhesions between tendons or between tendons and therefore the median nerve (Urbaniak and Desai 1996). Surgical drains may additionally diminish the incidence of adhesions, however, are related to a better rate of infection. If postoperative splints are used, removal of splints by postoperative Day three lessens the chance of adhesions by permitting early mobilization of the tendons. physiotherapy with range-of-motion exercises and dynamic splinting instead of tenolysis surgery is that the best treatment (Urbaniak and Desai 1996). as a result of the median nerve carries around seventieth of the sympathetic nerve supply to the hand, RSD might result from carpal tunnel decompression. MacDonald, et al.1978 reported four cases of RSD among thirty-four complications. additionally, they represented 3 stages of RSD within which the first stage is characterized by swelling, hyperesthesia, skin that's warm and dry, and chronic pain aggravated by movement. Progression to the second stage includes the proximal spread of pain and edema, shiny skin that's cool and pale with atrophic changes, and joint stiffness. The third stage manifests as progressive atrophy with joint contractures and intractable pain.

Early recognition and treatment are essential within the management of RSD. The initial medical aid includes a 1-week course of oral steroid and Stelazine medications accompanied by physiotherapy (Urbaniak and Desai 1996). This treatment typically resolves the syndrome, preclusive the requirement for stellate ganglion blocks. Pillar pain is an ill-defined , aching discomfort within the thenar and hypothenar eminences aggravated by gripping. Its etiology remains obscure however several attributes it to the transaction of the nerve fibers supply the palmaris brevis fascia and therefore the ensuing neuroma formation (Erdmann 1994). different doable mechanisms include widening of the carpal arch and realignment of the carpal bones (Gartsman et al 1986). Seradge and Seradge 1989 attributed persistent hypothenar eminence pain in 5 of five hundred patients to an abnormal piso-triquetral joint, that resulted from an intercarpal alignment change after ligament release. Deep wound infection was reported in seventeen patients at the Mayo Clinic. Statistically significant risk factors for the infections included intraoperative instillation of steroid agents into the carpal canal, flexor tendon synovectomy, prolonged operative time, and therefore the use of a surgical drain (Hanssen et al 1989). Treatment consists

mostly of surgical debridement with a primary closure or delayed primary closure once wound conditions allow. A suboptimal result occurred in seven of seventeen patients at final follow-up evaluation. Superficial infection rates are typically low compared with other surgical procedures. (Gainer and Nugent 1977) documented twenty-six "minor" infections in 430 operations. (Phalen 1966) reported one superficial infection in 212 cases. Bowstringing of the flexor tendons could be a rare, readily reparable complication in OCTR, cited in 2 of thirty-four complications by (MacDonald, et al. 1978). Bowstringing will typically be prevented by immobilizing the wrist joint in slight extension for three to five postoperative days. If bowstringing should occur, it may be simply corrected by reconstructing the TCL. (Jakab, et al. 1991) sectioned the ligament, reconstructed it with a lengthened ligament, and demonstrated resolution of CTS symptoms in ninety-three of patients who practised no loss of grip strength. Immediate postoperative loss of grip strength happens in all patients and persists in up to one-third of patients undergoing OCTR surgery. (Kluge, et al. 1996) evaluated grip strength at a minimum of ten months when surgery in sixty-six patients (89 hands) by subjective patient self-assessment. Grip strength was judged to be traditional in only forty-seventh. (Gellman, et al. 1989) measured the time course of recovery of grip and pinch strength using a dynamometer. Grip strength was expressed as a percentage of the preoperative ipsilateral grip strength. Grip strength was twenty-eighth of the preoperative level by three weeks; seventy-three by six weeks and returned to the preoperative level by three months. Loss of grip strength, scar tenderness, and persistent pillar pain are late sequelae of the OCTR procedure and have provided abundant of the impetus to modify to the choice of ECTR.

6-Conclusion

patients with recurrent carpal tunnel syndrome must be completely evaluated to exclude non-surgical conditions. Regarding surgical causes, there were four common intraoperative findings that occurred in the primary surgery: incomplete resection of the transverse carpal ligament, lack of adhenolysis procedure, and wound crossing of the proximal wrist crease and aggressive surgical excision of subcutaneous tissues in operative site.

7-References

Ariyan S, Watson HK (1977): The palmar approach for the visualization and release of the carpal tunnel. An analysis of 429 cases. Plast Reconst Surg 60:539-547,

Armstrong MB, Villalobos RE (1997) Surgical treatment of carpal tunnel syndrome. Phys Med Rehabil Clin N Am 8(3):529–539

Bande S, De Smet L, Fabry G (1994). The results of carpal tunnel release: open versus endoscopic technique. Journal of Hand Surgery, 19B: 14–17.

Beck JD, Brothers JG, Maloney PJ, Deegan JH, Tang X, Klena JC (2012). Predicting the outcome of revision carpal tunnel release. J Hand Surg Am. 2012;37:282–287.

Bilasy A, Facca S, Gouzou S, Liverneaux PA (2012). Canaletto implant in revision surgery for carpal tunnel syndrome: 21 case series. J Hand Surg Eur Vol.2012;37:682–689.

Bloem JJ, Pradjarahardja MC, Vuursteen PJ (1986). The post-carpal tunnel syndrome: causes and prevention. Neth J Surg;38:52–5. [PubMed]

Botte MJ, von Schroeder HP, Abrams RA, Gellman H (1996). Recurrent carpal tunnel syndrome. Hand Clinics, 12: 731–743.

Braun RM, Rechnic M, Fowler E (2002) Complications related to carpal tunnel release. Hand Clin 18(2):347–357

Brogmus GE and Marko R (1990): Cumulative trauma disorders of the upper extremities - the magnitude of the problem in U.S. industry. Proceedings of the IEA Conference on Human Factors in Design for Manufacturability and Process Planning,; Honolulu, Hawaii.

Carroll RE, Green DP (1972): The significance of the palmar cutaneous nerve at the wrist. Clin Orthop 83:24-28,

Concannon MJ, Brownfield ML, Puckett CL (2000). The incidence of recurrence after endoscopic carpal tunnel release. Plastic and Reconstructive Surgery, 105: 1662–1665.

Cseuz KA, Thomas JE, Lambert EH, et al (1966): Long-term results of operation for carpal tunnel syndrome. Mayo Clin Proc 41:232-241,

Demopulos GA, Urbaniak JR (1996) Carpal tunnel release: comparing the options. J Musculoskelet Med 13(9):51–58

Doyle JR, Carroll RE (1968): The carpal tunnel syndrome. A review of 100 patients treated surgically. Calif Med 108:263-267,

Duncan KH, Lewis RC Jr, Foreman KA, et al (1987): Treatment of carpal tunnel syndrome by members of the American Society for Surgery of the Hand: results of a questionnaire. J Hand Surg (Am) 12:384-391,

Erdmann MW (1994): Endoscopic carpal tunnel decompression. J Hand Surg (Br) 19:5-13,

Eversmann WW Jr (1986): Complications of compression of entrapment neuropathies, in Boswick JA (ed): Complications in Hand Surgery. Philadelphia: WB Saunders, pp 99-115

Favero KJ, Gropper PATIENT (1987): Ulner nerve laceration--a complication of carpal tunnel decompression: case report and review of the literature. J Hand Surg (Br) 12:239-241,

Gainer JV Jr, Nugent GR (1977): Carpal tunnel syndrome: report of 430 operations. South Med J 70:325-328,

Gartsman GM, Kovach JC, Crouch CC, et al (1986): Carpal arch alteration after carpal tunnel release. J Hand Surg (Am) 11:372-374,

Gelberman RH, Pfeffer GB, Galbraith RT, et al (1987): Results of treatment of severe carpal-tunnel syndrome without internal neurolysis of the median nerve. J Bone Joint Surg (Am) 69:896-903,

Gelberman RH, Rydevik BL, Pess GM, Szabo RM, Lundborg G (1988). Carpal tunnel syndrome. A scientific basis for clinical care. Orthopaedic Clinic of North America, 19: 115–124.

Gellman H, Kan D, Gee V, et al (1989): Analysis of pinch and grip strength after carpal tunnel release. J Hand Surg (Am) 14:863-864,

Gilbert MS, Robinson A, Baez A, Gupta S, Glabmann S, Haimov M (1988). Carpal tunnel syndrome in patients who are receiving long-term renal hemodialysis. Journal of Bone and Joint Surgery, 70A: 1145–1153.

Green R A and Briggs C A (1989): Effect of overuse injury and the importance of training on the use of adjustableworkstations by keyboard operators. Journal of Occupational Medicine; 31 (6): 557-562.

Hanssen AD, Amadio PC, DeSilva SP, et al (1989): Deep postoperative wound infection after carpal tunnel release. J Hand Surg (Am) 14:869-873,

Hybbinette CH, Mannerfelt L (1975): The carpal tunnel syndrome. A retrospective study of 400 operated patients. Acta Orthop Scand 46:610-620,

Ibrahim I, Khan WS, Goddard N, Smitham P (2012). Carpal tunnel syndrome: a review of the recent literature. Open Orthop J. 2012;6:69–76.

Jakab E, Ganos D, Cook FW (1991): Transverse carpal ligament reconstruction in surgery for carpal tunnel syndrome: a new technique. J Hand Surg (Am) 16:202-206,

Kerwin G, Williams CS, Seiler JG (1996) The pathophysiology of carpal tunnel syndrome. Hand Clin 12(2):243–251

Kluge W, Simpson RG, Nicol AC (1996): Late complications after open carpal tunnel decompression. J Hand Surg (Br) 21:205-207,

Kulick MI, Gordillo G, Javidi T, Kilgore ES Jr, Newmayer WL, III (1986). Long-term analysis of patients having surgical treatment for carpal tunnel syndrome. J Hand Surg (Am);11:59–66. [PubMed]

Langloh ND, Linscheid RL (1972): Recurrent and unrelieved carpal-tunnel syndrome. Clin Orthop 83:41-47,

Lanz U (1977): Anatomical variations of the median nerve in the carpal tunnel. J Hand Surg (Am) 1:44-53,

Learmonth JR (1993). The principles of decompression in the treatment of certain disease of peripheral nerves. Surgery Clinics of North America, 13: 905–913.

Levine DW, Simmons BP, Koris MJ et al (1993) A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. J Bone Joint Surg Am 75(11):1585–1592

Lilly CJ, Magnell TD (1985): Severance of the thenar branch of the median nerve as a complication of carpal tunnel release. J Hand Surg (Am) 10:399-402,

Louis DS, Greene TL, Noellert RC (1985): Complications of carpal tunnel surgery. J Neurosurg 62:352-356,

MacDonald RI, Lichtman DM, Hanlon JJ, et al (1978): Complications of surgical release for carpal tunnel syndrome. J Hand Surg (Am) 3:70-76,

Mackinnon SE, McCabe S, Murray JF, et al (1991): Internal neurolysis fails to improve the results of primary carpal tunnel decompression. J Hand Surg (Am) 16:211-218,

Martin CH, Seiler JG III, Lesesne JS (1996): The cutaneous innervation of the palm: an anatomic study of the ulnar and median nerves. J Hand Surg (Am) 21:634-638,

May JW Jr, Rosen H (1981): Division of the sensory ramus communicans between the ulnar and median nerves: a complication following carpal tunnel release. A case report. J Bone Joint Surg (Am) 63:836-838,

McDonald AP 3rd, Lourie GM (2005) Complex surgical conditions of the hand: avoiding the pitfalls. Clin Orthop Relat Res 433:65–71

Murphy Jr. RX, Jennings JF, Wukich DK. Major neurovascular complications of endoscopic carpal tunnel release. Journal of Hand Surgery,1994, 19A: 114–118.

Palmer AK, Toivonen DA (1999). Complications of endoscopic and open carpal tunnel release. Journal of Hand Surgery, 24A: 561–565.

Phalen GS (1966): The carpal tunnel syndrome. Seventeen years' experience in diagnosis and treatment of treatment of six hundred fifty-four hands. J Bone Joint Surg (Am) 48:211-228,

Phalen GS (1970). Reflections on 21 years' experience with the carpaltunnel syndrome. Journal of the American Medical Association, 212: 1365–1367.

Phalen GS (1972): The carpal-tunnel syndrome. Clinical evaluation of 598 hands. Clin Orthop 83:29-40,

Phalen GS (1981). The birth of a syndrome, or carpal tunnel revisited. Journal of Hand Surgery, 6A: 109–110.

Poisel S (1974): Ursprung und Verlauf des R. Muscularis des Nervus digitalis palmaris communis (N. medialis). Chir Praxis 18:471-474,

Rowland EB, Kleinert JM (1994): Endoscopic carpal-tunnel release in cadavers. An investigation of the results of twelve surgeons with this training model. J Bone Joint Surg (Am) 76:266-268,

Semple JC, Cargill AO (1969): Carpal-tunnel syndrome. Results of surgical decompression. Lancet 1:918-919,

Seradge H, Seradge E (1989): Piso-triquetral pain syndrome after carpal tunnel release. J Hand Surg (Am) 14:858-862,

Snook S (1990): Cumulative trauma disorders. Liberty Mutual Research Center, Hopkinton, MA. (Unpublishedlecture notes)..

Steinberg DR (2002) Surgical release of the carpal tunnel. Hand Clin 18(2):291–298

Terrono AL, Belsky MR, Feldon PG, et al (1993): Injury to the deep motor branch of the ulnar nerve during carpal tunnel release. J Hand Surg (Am) 18:1038-1040,

Urbaniak JR, Desai SS (1996): Complications of nonoperative and operative treatment of carpal tunnel syndrome. Hand Clin 12:325-335,

Wilson JK, Sevier TL (2003) A review of treatment for carpal tunnel syndrome. Disabil Rehabil 25(3):113–119

Wulle C (1987). Treatment of recurrence of the carpal tunnel syndrome. Annals Chirurgie de la Main, 6: 203–209.