

tion rate of the stimulus decreases. Distal latency time for the abductor pollicis brevis, when stimulated at the wrist, ranges between 2.2 and 4.3 milliseconds. In 85% of cases of CTS, latency time is considerably increased.

## TREATMENT

Conservative methods fail to produce positive results. Patients who prefer not to undergo surgery may obtain a temporary improvement by wrist immobilization or a local cortisone injection. Sometimes a change of jobs is sufficient to relieve discomfort.

Surgical treatment consists in the decompression of the median nerve at the level of the carpal tunnel. We perform the procedure under tourniquet control. So far we have only used brachial plexus anesthesia, in accordance with Kulendaff's technique. We still lack enough experience of intravenous local anesthesia.

An oblique incision is made on the anterior aspect of the wrist, which is continued towards the hand following the internal border of the thenar eminence. We firstly isolate the nerve above the tunnel, which can be done easily by taking as a reference the tendons of the palmaris longus and palmaris brevis muscles. Once the median nerve has been identified, its course is followed until it enters the tunnel. At that point, the transverse ligament must be sectioned. The motor horns associated to the muscles of the thumb must be examined in all cases. The transverse ligament must be sectioned from beginning to end. When no alterations to the tendon sheaths are found, the only requirement is to suture the skin with as little tension as possible. In some cases, Kalman sections the tendon of the palmaris brevis muscle, a maneuver we do not consider necessary. Once the skin has been sutured, we apply a compressive bandage and a plaster cast, which are retained for 10 days, deflating the tourniquet once the bandage is fully in place.

Relief of preoperative pain is normally immediate. Return of sensitivity depends on the duration of symptoms preoperatively. In cases operated early sensitivity returns a few days after surgery. Otherwise, months can elapse before normal sensitivity is achieved. Recovery of opponens pollicis function takes longer and even in cases of full recovery some marginal muscle atrophy usually remains.

In the literature reviewed, statistics are unanimous in terms of the results afforded by the procedure. Generally, the percentage of good results (disappearance of pain, return of sensitivity and recovery of opponens function) ranges from 80 to 85%. Our experience is generally in line with that of other authors. Nevertheless, our number of cases is still low and therefore not yet statistically significant.

## SUMMARY

In this study we have presented a detailed study of the carpal tunnel syndrome since we condition that this is an ill-known condition. Our work is based on a review of the international literature published to date and on the analysis of our clinical material. We emphasize the importance of early diagnosis and report of modern diagnostic techniques used by the author. Lastly, the surgical technique is described.

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## Comment

Forty years after Dr. Rico Agudo wrote his paper, carpal tunnel syndrome (CTS) has become a different entity, not only in terms of its prevalence among the general population but also as regards its diagnosis and treatment.

Nowadays, CTS is the most frequent condition involv-

ing the wrist and affects approximately 10% of women between 45 and 55 years of age; one-third of cases are bilateral. As regards its origin, if we exclude cases secondary to bone pathology (post-traumatic distal radius deformities) and of static space occupancy (rheumatoid arthritis or amy-

lodosis in patients receiving hemodialysis for example), in these 4 decades it has been observed that the incidence of CTS increases with the performance of repetitive activities and with job-related overuse. Certain currently widespread manual occupations (cleaning or assembly-line jobs for example) inherently lead to an increase of intraneural median nerve pressure (effects of dynamic space occupancy by the lumbrical muscles) that is not followed by a pressure reduction stage. Nevertheless, most cases of CTS occur in women who do not perform any kind of overloading physical activity, which means that the factors involved in the etiology of the condition are multiple (diabetes, etc.)<sup>1-3</sup>.

The symptoms reported by the patient are obviously the same as in 1968: numbness of the rays innervated by the median nerve with normal sensitivity in the area of the palmar cutaneous branch of the median nerve, and constrictive pain in the rays, especially in the middle finger; all of this occurs predominantly at night. Back then, it was known that the nocturnal nature of the pain was due to several factors, such as: a) the wrist flexor tone of higher mammals is such that during sleep rotational changes occur in the pisiform and scaphoid bones that decrease the volume of the carpal tunnel by 20%, increasing its internal pressure and reducing nerve perfusion; b) the lying position gives rise to an accumulation of fluids in the interstitial space, which leads to an increase in the canal's internal pressure; c) the lack of dynamic recirculation due to the stillness of sleep perpetuates fluid accumulation in the upper limbs; and d) tissue perfusion pressure in the is at its lowest in the early morning, which decreases perfusion to all tissues, including the nervous tissue<sup>2</sup>.

Most physicians devoted to hand surgery consider that patient symptoms are the most significant information available for diagnosis.

Clinical examination is a compulsory element in the diagnosis of CTS. An analysis of the cutaneous sensitivity of the median nerve area must be included in the study of a hand suspected of being affected with CTS. The 2-point discrimination test and, especially, the changes in sensitivity caused by Wartemberg's esthesiometer, gave high diagnostic value, especially when a comparison is made with the normal sensitivity of the neighboring territories (palmar cutaneous branch of the median nerve and ulnar region) or with the TAME territory in the contralateral hand. At that time, Phalen already introduced his wrist flexion test which is still a diagnostic standard of high predictive value. More recently, Durkan developed a carpal compression test, which has a similar predictive value. The classic Tinel test is highly specific at early stages and on highly advanced ones (proximal pseudoneuroma), but has very low sensitivity since it is positive in one third of cases of CTS. There are up to 30 useful elicitation tests, some of them of high sensitivity such as the tourniquet test or the repeated flexion and extension of the wrist (lumbricals test)<sup>1,4</sup>.

There is no doubt that in some cases a simple inspection of the hand can be indicative of the presence of CTS: thenar eminence atrophy (paresis of the abductor pollicis brevis) clearly suggests long-standing compressive neuropathy. However, in less evident cases, an analysis of strength by way of the carpal compression test or by pollux-specific dynamometric tests could be of use. Some of these CTS patients also present with degenerative alterations to the thumb column that might lead to error in interpreting strength tests<sup>1</sup>.

The anamnesis stage must never be omitted, even if the patient submits an electroneurophysiological study. Although electroneurophysiology is a science based on numerical evidence, 15% of such studies are normal in patients with evident CTS symptoms. Most of these symptoms disappear on surgically decompressing the carpal tunnel. On the other hand, almost 45% of normal individuals present some alteration in some of the parameters studied, especially in their dominant hand. My personal opinion, not shared by all experts in the field, is that with an accurate anamnesis and the appropriate elicitation clinical tests (wrist flexion test, compression test and lumbricals test) 95% of cases of CTS can be diagnosed, with high specificity and sensitivity levels. Do electrodiagnostic studies play any role? Obviously, In doubtful cases, when a double crush syndrome is suspected or in patients where the lack of specific figures about their condition could lead to a lawsuit with economic implications<sup>1,3,4</sup>.

For the most part, treatment of CTS has not undergone any changes since the 1960's. Open surgery is still the standard treatment of choice for CTS patients whose pain profile —especially in terms of their night-time pain, which is the reason why most CTS patients consult a physician — does not improve after a 6-9 months period with postural rest (nocturnal wrist splint), functional hand readaptation, non steroid antiinflammatory drugs (NSAIDs), physical therapy or local infiltration. In the last few years, studies of the microanatomy of the palm of the hand have made it possible to establish the design and location of the cutaneous incisions into the carpal tunnel, with two goals in mind: a) prevent morbidity during the process of wound healing and b) prevent accidental lesions. Classical incisions into the thenar fold, extending proximally towards the radial region of the wrist, such as the one described in figure 6 of Dr. Rico Agudo's paper — must be avoided in order not to injure the palmar cutaneous branch of the median nerve, which would provoke a painful and difficult-to-treat neuroma. Too radial an approach could lead to opening the flexor retinaculum too close to the emergence of the thenar motor branch of the median nerve, which is of a transligamentous nature in 25% of cases and subligamentous with distal-radial recurrence in 31%. Opening the flexor retinaculum «blindly» with scissors through small proximal incisions into the

wrist flexor fold must also be avoided, as should excessively wide incisions. Although wide incisions, if proximally directed towards the ulnar side (i.e. not damaging the palmar cutaneous branch of the median nerve), are preferable to mini-incisions and are recommendable when a flexor tenosynovectomy must be carried out, as for example in cases of inflammatory arthropathy<sup>1</sup>.

Where is the truth? As the classics would have it, the truth is generally in the middle, that is, the incision should be made on the flexor retinaculum (the axis of the third commissure, the least densely sensorily innervated area in the skin) and without surpassing the wrist flexor fold (in this way lesions to the branch communicating the palmar cutaneous branch of the median nerve and the first transverse cutaneous branch of the ulnar nerve, present in 50% of individuals, can be averted). And, naturally, the incision length should be neither too short neither excessively long, i.e. around 3.5 cm, taking into account that under the skin incision lies the flexor retinaculum. So we might ask ourselves why we should operate from a distance without enough visibility and without feeling safe about what we are doing. Is an incision of 2 cm associated with a higher success rate or lower morbidity than a 3.5 cm one? These mini-incisions and approaches from a distance have generated, and still do, severe iatrogenic lesions (partial or total sections of the median and ulnar nerves), as well as incomplete openings of the flexor retinaculum<sup>5</sup>. A recent study by Stütz et al<sup>5</sup> reports that 54% of cases requiring secondary surgery presented with incomplete opening of the flexor retinaculum, especially in its distal portion, i.e. an inappropriate technique that could have been avoided.

Once the soft tissues have been exposed, authors unanimously recommend sectioning the flexor retinaculum at its ulnar border, next to the unciform process of the hamate bone so that healing inherent in the normal tissue repair process stays away from the median nerve, located on the radial side of the carpal tunnel. What should be done with the median nerve? Either nothing at all or perhaps separate it gently with a blunt instrument from the adhesions to the walls of the carpal tunnel<sup>1</sup>. This open exploration is enough to identify the pathology concealed inside the carpal tunnel and to determine the anatomical variables of the attachment of the opponens digiti minimi, which could be factors involved in the dynamic compression of the distal portion of the median nerve<sup>6</sup>.

Although symptoms disappeared completely in over 95% of cases of CTS operated with open surgery, a series of instrumental systems were introduced in the 1980's for performing non-open release of the carpal tunnel. These designers suggested that a kind of decompression that did not require access to the carpal tunnel through the peripheral tissues might speed up recovery and decrease treatment costs. On the basis of the advances made in endoscopy and

of sound design principles, release techniques were developed that used mini-approaches and direct view of the flexor retinaculum through the carpal canal. The last decade saw the introduction of about 2 dozen minimally invasive techniques for endoscopically sectioning the flexor retinaculum with wide-ranging results among their designers and the independent surgeons that put them into practice. As a result of the criticism it has received in the last 10 years because of the few advantages it affords, the endoscopic technique is only used by a handful of highly experienced surgeons with a success rate similar to that of open surgery, but with a far higher risk of accidental lesions. Furthermore, this therapeutic technique is more extensive than conventional open surgery<sup>7</sup>.

Given the enormous prevalence of CTS in the population and the generalization of healthcare in the developed world, CTS surgery has become extremely common. Nonetheless, this has resulted in a seemingly paradoxical high incidence of recurrences, which cause a difficult-to-solve problem. As regards the precise meaning of the word recurrence, the dictionary defines it as the return of a condition after remission. In this connection, it would seem that recurrences arise because of some new compressive event probably caused by factors related to wound healing, more specifically traction, lack of sliding or circumferential wrapping of the median nerve, which accounts for one-third of secondary CTS surgeries. On the basis of this information one might wonder how many of these recurrences could be avoided by carrying out a meticulous technique and an appropriate opening of the retinaculum<sup>5</sup>. The response is clear: most of them.

To conclude, in spite of the 40 years elapsed since its publication, Dr. A. Rico's paper for the most part retains its scientific value. What time has done is to provide a scientific basis for the different diagnostic and therapeutic aspects of CTS.

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