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Original

Analysis of the management of carpal tunnel syndrome: management, treatment and outcomes

Análisis del manejo del síndrome del túnel carpiano: manejo, tratamiento y resultados

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ABSTRACT

Background: *Carpal tunnel syndrome (CTS) is a prevalent neuropathy resulting from compression of the median nerve as it traverses the carpal tunnel in the upper extremities. The study focused on patients exhibiting symptoms such as tingling, paresthesia, and motor impairment due to median nerve compression, who underwent surgical decompression.*

Materials and Methods: *This retrospective observational study involved 45 patients (34 women and 11 men) range of age 18-75 years old. After the evaluation and the failure of conservative treatments and the decision-making process for surgical intervention. At the City Clinical Hospital Nº68 Gbuz Gkb Im. V.P. Demikhova. Diagnosis was confirmed through physical examination and ultrasound imaging before proceeding with surgical intervention to achieve optimal postoperative outcomes.*

Results: *This study included N=45 patients, consisting of 34 women and 11 men, with an age range of 38 to 85 years, the symptomatically N=12 patients (26.6%) reported numbness, tingling, and reduced motor skills in the first two fingers. Fourteen patients (31.11%) experienced numbness, tingling, and impaired fine motor skills in the first three fingers of the left hand, accompanied by muscle atrophy.*

Conclusion: *Postoperative outcomes were favorable, with resolution of pain syndrome and no neurological deterioration beyond the preoperative status.*

Keywords: *carpal tunnel syndrome; paresthesia; neuropathy; median nerve; diagnosis and outcomes.*

RESUMEN

Introducción: *El síndrome del Túnel carpiano (STC) es una neuropatía prevalente que resulta de la compresión del nervio mediano a medida que atraviesa el túnel carpiano en las extremidades superiores. El estudio se centró en pacientes que presentaban síntomas como hormigueo, parestesias y deterioro motor debido a la compresión del nervio mediano, y que fueron sometidos a descompresión quirúrgica.*

Materiales y métodos: *Este es un estudio observacional retrospectivo que incluyó 45 pacientes (34 mujeres y 11 hombres) con un rango de edad de 18 a 75 años. Tras la evaluación, el fracaso de los tratamientos conservadores y el proceso de toma de decisiones para la intervención quirúrgica. Los pacientes fueron tratados en el Hospital Clínico Municipal n.º 68 (GBUZ GKB im. V. P. Demikhova). El diagnóstico se confirmó mediante exploración física y ecografía antes de proceder con la intervención quirúrgica, con el objetivo de lograr resultados postoperatorios óptimos.*

Resultados: *Este estudio incluyó N = 45 pacientes, 34 mujeres y 11 hombres, con un rango de edad de 38 a 85 años. En cuanto a la sintomatología, N = 12 pacientes (26,6%) informaron entumecimiento, hormigueo y disminución de la capacidad motora en los dos primeros dedos. Catorce pacientes (31,11%) presentaron entumecimiento, hormigueo y alteración de la motricidad fina en los tres primeros dedos de la mano izquierda, acompañados de atrofia muscular.*

Conclusión: *Los resultados postoperatorios fueron favorables, con resolución del síndrome doloroso y sin deterioro neurológico más allá del estado preoperatorio.*

Palabras clave: *síndrome del túnel carpiano; parestesia; neuropatía; nervio mediano; diagnóstico y resultados.*

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1 INTRODUCTION

Carpal tunnel syndrome (CTS) is a prevalent neuropathy caused by compression of the median nerve as it passes through the carpal tunnel in the upper extremities. It commonly manifests as pain and paresthesia within the median nerve distribution, including the palmar aspect of the thumb, the index and middle fingers, and the radial half of the ring finger[1,2]. These injuries are frequently caused by degenerative wear and tear due to repetitive forced movements, leading to an increase in volume and pressure within the carpal tunnel and subsequent compression of the median nerve by surrounding structures[3]. When conservative treatments fail, surgical intervention becomes necessary, with options including open surgery or endoscopic release of the flexor retinaculum. A promising alternative is minimally invasive, ultrasound-guided percutaneous decompression, which offers advantages in precision and recovery time compared to traditional surgical methods[4]. Furthermore, anatomical factors, such as malunion of the distal radius, have been linked to a predisposition for late-onset CTS. Radial deformities such as radial inclination <10°, volar inclination >20°, dorsal inclination >20°, radial height <10 mm, ulnar variance >2+, or an intra-articular step-off >2 mm are associated with increased risk[5]. The aim of this study is to analyze the prevalence, direction, and characteristics of paresthesia and/or tingling in patients undergoing surgical intervention and functional outcomes postoperatively.

2 MATERIAL AND METHODS

This retrospective observational study involved 45 patients, comprising 34 women and 11 men, with an age range of 18 to 75 years, while evaluate the failure of conservative treatments and the decision-making process for surgical intervention. The study adhered strictly to the ethical guidelines outlined in the Declaration of Helsinki and Good Clinical Practices, ensuring the protection of participants' rights, January 2017 and September 2025.

3 RESULTS

The study included N=45 patients, consisting of 34 women and 11 men, the symptomatically, N=12 patients (26%) reported numbness, tingling, and reduced motor skills in the first two fingers. N=14 patients (31%) experienced numbness, tingling, and impaired fine motor skills in the first three fingers of the left hand, accompanied by muscle atrophy. Additionally, N=19 patients (42%) presented with numbness, tingling, and burning sensations on the palmar surface of the hand, affecting fingers 1–4, along with decreased sensitivity in the right hand (Tables 1-3, Figures 1, 2, 3).

In terms of neuropathic involvement, the right hand was predominantly affected, with 21 patients (46.6%) showing signs of carpal tunnel pathology. The left hand was affected in 12 patients (26.6%), and bilateral neuropathy was observed in 12 patients:

- Predominantly right-sided in 3 patients (6.67%).
- Predominantly left-sided in 1 patient (2.22%).
- Equitably bilateral in 8 patients (17.77%).

These findings highlight the varied presentations and distribution patterns of neuropathic involvement in patients with carpal tunnel syndrome, with a notable predisposition towards right-hand dominance (Tables 2-3, Figures 2, 4, 5, 6, 7).

4 DISCUSSION

The most common atrophy of the hands is carpal tunnel syndrome (CTS). It is prevalent in the general population, affecting 3.8%. Patients with CTS have experienced numbness and discomfort within a 6-month period, and even after adequate conservative treatment, they often require surgical intervention. Surgery is performed in 31% to 40% of patients with this CTS condition. When the patient presents with significant compression and atrophy of the thenar muscles, urgent decompression is required for optimal recovery. Minimally invasive surgery has reshaped the approach to carpal tunnel syndrome, shifting from a traditional

Table 1. Management of Patients with Carpal Tunnel Syndrome (CTS), by Location and most affected Regions, through Surgical treatment and follow-up during the Postoperative period.

PantientsNo.	Ultrasounds	Diagnosis	Age	Compression	neuropathy	Complaints	Approaches	Signs	Associated pathologies	Follow up
1	Yes	CTS	65	median nerve	On the left	Numbness, tingling, decreased fine motor skills in 1-3 fingers of the left hand, hand muscle atrophy	Decompression of the median nerve at the level of the carpal tunnel on the right	Tinel's and Phalen's symptoms on the left. Hypotrophy of the thenar muscles on the left.	N/A	1 month
2	Yes	CTS	84	Yes	on the right	numbness, burning, tingling in the 2- medial surface of the 4th finger	Yes	N/A	lumbar spine, stenosis L4-L5 disc, right-sided	1
3	Yes	CTS	62	Yes	on the right	Feeling of numbness, tingling, burning on the palmar surface of the hands, fingers 1-4, decreased sensit4 ity, in the right hand	Yes	Tinel's symptom	N/A	1
4	Yes	CTS	71	Yes	on the right	pain in the right hand, numbness of 1-3 fingers of the right hand	Yes	Yes		1
5	Yes	CTS	57	Yes	on the right	pain in the right wrist radiating to the forearm, most pronounced at night, numbness of the 1-3 fingers of the right hand	Yes	Yes	Signs of left atrial hypertrophy.	1
6	Yes	CTS bilateral	66	Yes	on both sides, more pronounced on the right	Numbness of fingers 1-4 of the right and left hands, more pronounced on the right	Yes	Yes	left ventricular hypertrophy.	1 month
7	Yes	CTS bilateral	74	Yes	on both sides	numbness and paresthesia in the 1-3 and radial half of the 4 fingers of both hands, more on the right	Yes	Yes	type 2 diabetes mellitus, rheumatoid arthritis	1 month
8	Yes	CTS bilateral	74	Yes	on both sides	pain in the area of the right wrist, decreased sensit4 ity and paresthesia of 1-4 fingers of the right and lef thand,	Yes	N/A	type 2 diabetes. Stage 2 hypertension	1

N/A: not applied.

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Table 1. Continued...

PatientsNo.	Ultrasounds	Diagnosis	Age	Compression	neuropathy	Complaints	Approaches	Signs	Associated pathologies	Follow up
9	Yes	CTS	68	Yes	on the right	pain in the area of the right wrist, decreased sensit4 ity and paresthesia of fingers 1-4 of the right hand, mainly at night	Yes	N/A	N/A	1
10	Yes	CTS	69	Yes	On the left	pain in the area of the left wrist, decreased sensit4 ity and paresthesia of the 1-3 fingers of the left hand, mainly at night	Yes	Yes	hypertension stage 2	1
11	Yes	CTS bilateral	67	Yes	both sides	pain in the area of the left wrist, decreased sensit4 ity and paresthesia of the 1-3 fingers of the left han	Yes	Yes	hypertension stage 2	1
12	Yes	CTS	81	Yes	On the left	pain in the area of the left wrist, paresthesia of the 1-3 fingers of the left hand	Yes	Yes	N/A	1
13	Yes	CTS	56	Yes	on the right	pain in the area of the right wrist, decreased sensit4 ity and paresthesia of fingers 1-4 of the right hand,	Yes	N/A	hypertension stage 2	1
14	Yes	CTS	62	Yes	on the right	pain in the area of the right wrist, decreased sensit4 ity and paresthesia of fingers 1-4 of the right hand	Yes	N/A	hypertension stage 2	2-3 weeks
15	Yes	CTS	74	Yes	On the left	pain in the left wrist, decreased sensit4 ity and paresthesia of fingers 1-4 of the left hand, mainly at night	Yes	N/A	type 2 diabetes	1
16	Yes	CTS bilateral	53	Yes	Both sides	pain in the area of the right and left wrist joint, decreased sensit4 ity and paresthesia of fingers 1-4 of the right and left hand	Yes	N/A	intervertebral disc herniation at the L5-S1 level on the right	1
17	Yes	CTS	55	Yes	On the right	pain in the right wrist, pain and numbness in the I-4 fingers of the right hand	Yes	Yes	C5-C6 and C6-C7	1

N/A: not applied.

Table 1. Continued...

PatientsNo.	Ultrasounds	Diagnosis	Age	Compression	neuropathy	Complaints	Approaches	Signs	Associated pathologies	Follow up
18	Yes	CTS	75	Yes	On the right	pain in the right wrist, numbness of fingers 1-4 of the right hand	Yes	Yes	N-A	1
19	Yes	CTS	52	Yes	On the left	pain in the left wrist, numbness of fingers 1-4 of the left hand.	Yes	Yes	N/A	1
20	Yes	CTS	60	Yes	On the left	pain in the left hand, numbness of fingers 1-4 of the left hand.	Yes	Yes	N-A	1
21	Yes	CTS	56	Yes	On the right	pain in the area of the right wrist, decreased sensit4 ity and paresthesia of fingers 1-4 of the right hand	Yes	N/A	hypertension stage 2	1
22	Yes	CTS	38	Yes	On the left	pain in the wrist area, more on the left, numbness of the fingers of the left hand.	Yes	Yes	N/A	1
23	Yes	CTS	85	Yes	On the right	pain in the right wrist, numbness of fingers 1-4 of the right hand	Yes	Yes	N/A	1
24	Yes	CTS bilateral	58	Yes	Both sides	pain in the left and right hands, numbness of 1-3 fingers of the left and right hands, more in the right hand	Yes	Yes	type 2 diabetes	1
25	Yes	CTS	64	Yes	On the left	numbness and paresthesia in the 1-4 fingers of the left hand, pain in the left wrist	Yes	Yes	N/A	1
26	Yes	CTS	59	Yes	On the right	pain and numbness in the right hand	Yes	Yes	N/A	1
27	Yes	CTS bilateral	77	Yes	Both sides	numbness and paresthesia in the 1-3 and radial half of the 4 fingers of both hands, more on the righ	Yes	Yes		1
28	Yes	CTS bilateral	47	Yes	Both sides	Pain in the wrist joints, numbness of the fingers, mainly 1-4 .	Yes	Yes	N/A	1
29	Yes	CTS	72	Yes	On the right	pain and numbness in the right hand 1-3 radial side of the 4 finger	Yes	Yes		1

N/A: not applied.

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Table 1. Continued...

PatientsNo.	Ultrasounds	Diagnosis	Age	Compression	neuropathy	Complaints	Approaches	Signs	Associated pathologies	Follow up
30	Yes	CTS bilateral	64	Yes	Both sides	pain in the area of the right and left wrist joint, decreased sensit4 ity and paresthesia of 1-4 fingers of the right and left hands	Yes	Yes	Calcifications in the apex of both lungs	1
31	Yes	CTS	82	Yes	On the left	pain in the left wrist, decreased sensit4 ity and paresthesia of the 1-3 fingers of the left hand	Yes	Yes	coronary heart disease, stage 2 hypertension.	1
32	Yes	CTS	48	Yes	On the right	pain in the left wrist, decreased sensit4 ity and paresthesia of the 1-3	Yes	N-A	stage 2-3 hypertension.	1
33	Yes	CTS	53	Yes	On the right the Quervain's syndrome on the left	pain in the area of the right wrist, numbness of the fingers of the right hand, pain in the left hand in the area of the head of the 1st metacarpal bone and limited mobility of the 1st finger of the left hand.	Yes	Yes	N/A	1
34	Yes	CTS	80	Yes	On the right	pain and numbness in the hands, more on the right	Yes	Yes	Hypertension stage 3	1
35	Yes	CTS bilateral	58	Yes	Both sides	pain and numbness in the hands	Yes	Yes	Hypertension stage 2	1
36	Yes	CTS	58	Yes	On the right	numbness of the 1-3 and radial half of the 4 fingers of the right hand, pain in the right wrist.	Yes	Yes	N/A	1
37	Yes	CTS bilateral	74	Yes	On the left	pain in the left wrist, decreased sensit4 ity and paresthesia of fingers 1-4 of the left hand	Yes	Yes	Type 2 diabetes	1
38	Yes	CTS	74	Yes	On the right	pain in the left wrist, decreased sensit4 ity and paresthesia of fingers 1-4 of the left hand, mainly at night	Yes	Yes	Type 2 diabetes	1
39	Yes	CTS	86	Yes	On the left	pain and numbness in the left hand	Yes	Yes	N/A	1

N/A: not applied.

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Table 1. Continued...

PatientsNo.	Ultrasounds	Diagnosis	Age	Compression	neuropathy	Complaints	Approaches	Signs	Associated pathologies	Follow up
40	Yes	CTS	61	Yes	On the right	pain and numbness in the hands, more in the right	Yes	Yes	Type 2 diabetes	1
41	Yes	CTS	57	Yes	On the right	pain and numbness in the right hand	Yes	Yes	N-A	1
42	Yes	CTS	67	Yes	On the right	pain in the area of the right wrist, decreased sensit4 ity and paresthesia of the 1-3 fingers of the right hand	Yes	Yes	hypertension stage 2	1
43	Yes	CTS	62	Yes	On the left	pain in the left wrist, numbness of 1-3 fingers of the left hand	Yes	Yes	decompression of the right median nerve	1
44	Yes	CTS	85	Yes	On the left	pain in the left wrist, pain and numbness in the 1-3 fingers of the left hand	Yes	Yes	carpal tunnel syndrome on the right	1
45	Yes	CTS	64	Yes	On the right	pain in the right wrist, mainly at night, numbness in the 1-3 fingers of the right hand	Yes	Yes	diabetes mellitus and hypertension/ carpal tunnel syndrome on the right	1

N/A: not applied.

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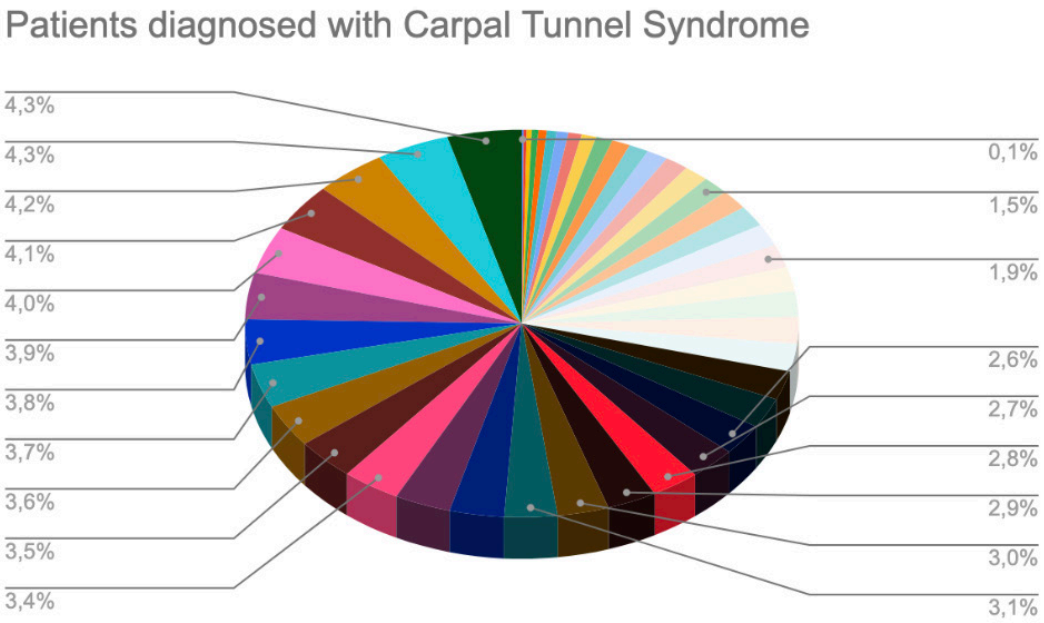

Figure 1. Graphic representation of the management of patients with Carpal Tunnel Syndrome.

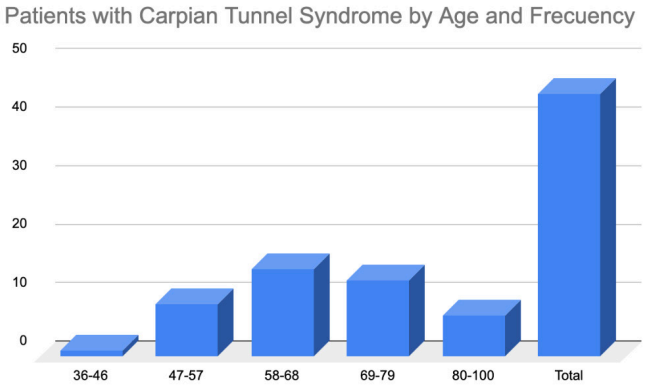

Figure 2. Symptoms of carpal tunnel syndrome affected by physiological and anatomical frequency according to the age of the patients.

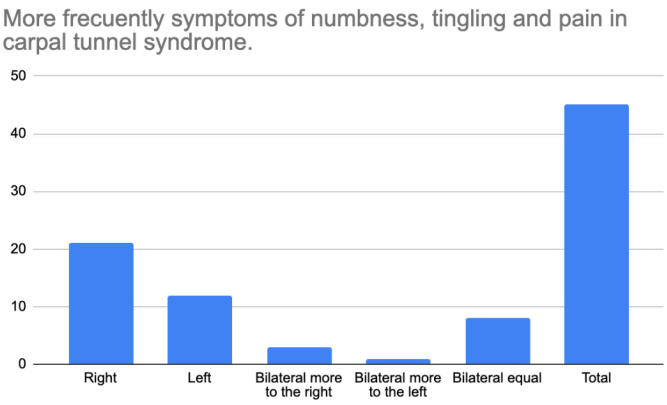

Figure 3. The most frequently affected region of carpal tunnel syndrome is the right wrist.

Table 2. Carpal tunnel syndrome: frequency by age affected.

Age	Frequency	Percent (%)
36-46	1	2.22
47-57	9	20
58-68	15	33.33
69-79	13	28.88
80-100	7	15.56
Total	**45**	**100%**

Table 3. Most frequent location of numbness, tingling and pain in carpal tunnel syndrome.

Localization	Frequency	Percent (%)
Right	21	46.6
Left	12	26.6
Bilateral more to the right	3	6.67
Bilateral more to the left	1	2.22
Bilateral equal	8	17.77
Total	**45**	**100%**

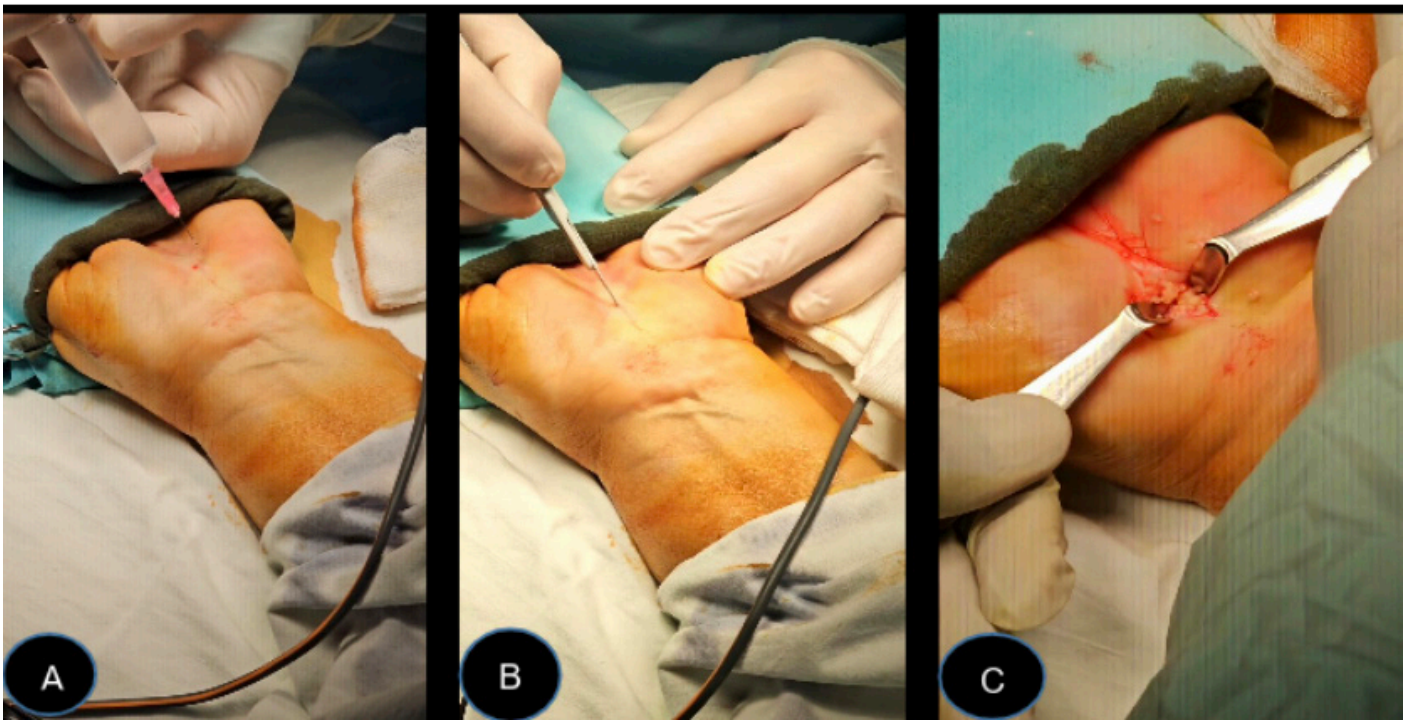

Figure 4. (a) The hand is sterilized and blocked with a 10 cc syringe containing 0.5 cc of lidocaine or novocaine; (b) A 1-4 cm incision is made; (c) The anatomical structures are expanded with retractors for a better approach.

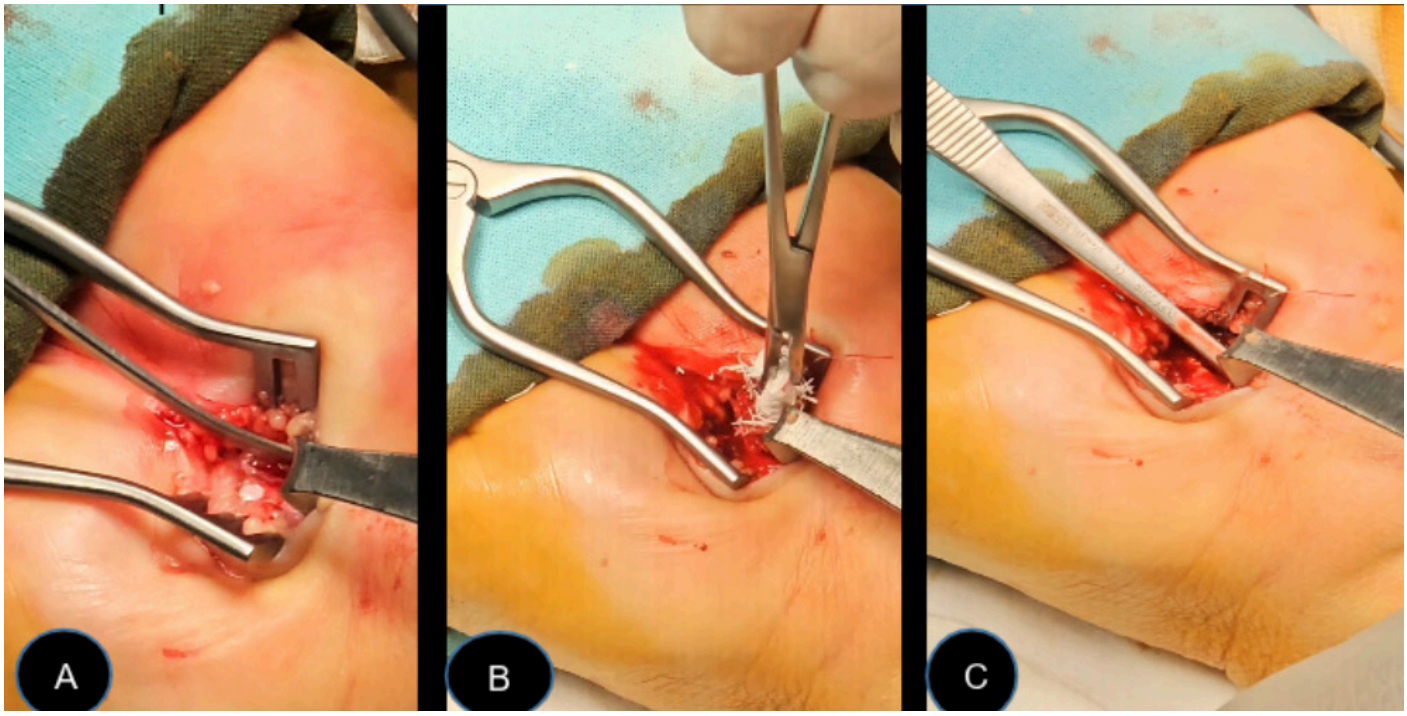

Figure 5. (a) proceed to enlarge the surgical wound by separating the tissue; (b) We dry and separate the palmar fibers to visualize the dissected carpal ligament; (c) We insert the spatula under the proximal ligament for its release.

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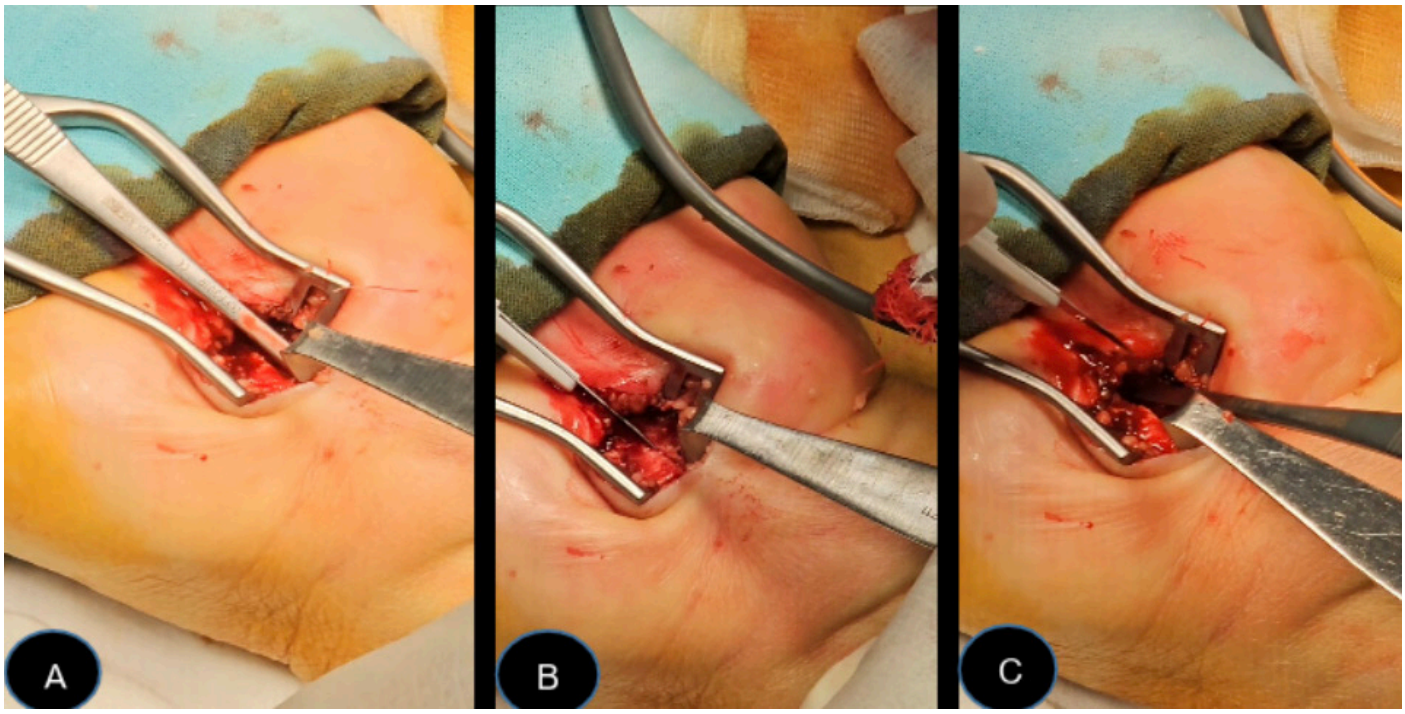

Figure 6. (a) The spatula is inserted to retract the tendons and the median nerve; (b) Using the scalpel, we extend the approach proximally; (c) After drying the ligament we separate with scissors,and proceed to confirmate the decompressed canal with the spatula.

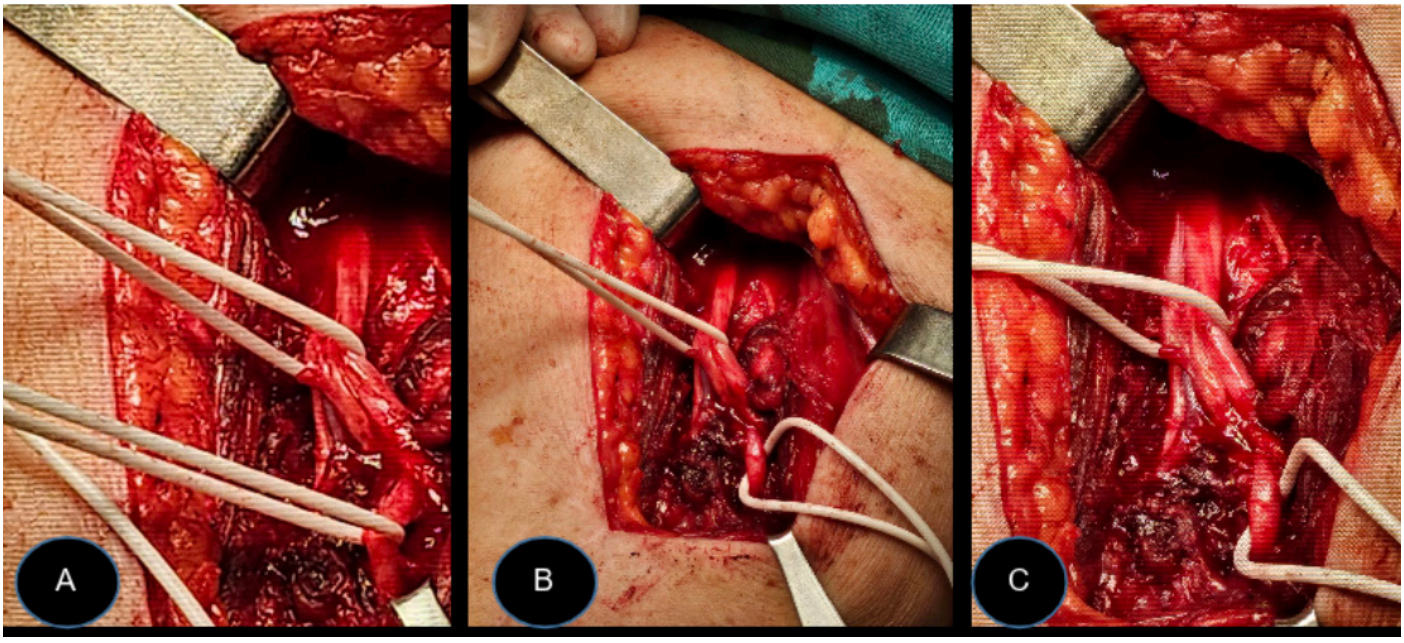

Figure 7. (a) Example of peripheral nerve entrapment of the radial nerve at the level of a humerus fracture; (b) Anatomical approach and dissection of the radial nerve; (c) Decompression of the radial nerve and adjacent structures by surgical reconstruction. (Holstein-Lewis fracture).

paradigm to a minimally invasive approach, offering greater benefits for the patient and improved postoperative recovery[6].

Pathophysiology

There are several theories regarding the pathogenesis of carpal tunnel syndrome (CTS). The main one is that it is due to mechanical compression, as well as microvascular insufficiency or vibration. According to the mechanical theory, its symptoms are due to compression of the median nerve in the carpal tunnel. One drawback is that it clarifies the consequences of carpal compression but not the parallel etiology of mechanical compression. Some authors asserted that the symptoms of spontaneous compression of the median nerve in the tunnel are spontaneous. They considered it so because the role of wrist joint deformities in the symptoms was not clear. Among the contributing factors, strain from exertion or overuse, hyperventilation, and prolonged repetitive wrist extension were attributed to it, as well as prolonged gripping and the use of manual or habitual tools. Microvascular insufficiency not only causes a deficiency of nutrients and oxygen in the nerve but also impairs its ability to transmit nerve impulses, leading to the formation of scar tissue and fibrous tissue[7].

Physiology and pathophysiology

Dorsal root ganglion

The dorsal root ganglion (DRG) is essential in the sensory transduction and modulation model of pain, as it contains the cell bodies of primary sensory neurons, which are structured with approximately 15,000 cell bodies, a number eight times greater than that of glial cells. Peripheral nerves, lacking a blood-brain barrier, are more vulnerable to the radiation of biochemical agents[8,9].

Axonal transport

Axonal transport is an energy-dependent structure responsible for transporting various substances necessary for synthesizing neuronal structures from the cell bodies to the distal or terminal parts of the axon, both anterograde and retrograde. These substances include neurotransmitters and components of the cytoskeleton. When we have prolonged compression lasting more than 8 hours with only 20 mmHg, we can decrease rapid anterograde axonal transport; however, a two-hour compression of 30 to 50 mmHg can block axonal transport, which can be reversible within 48 hours. If the compression lasts two hours at 200 mmHg, it may be reversible in about three days. The same applies to retrograde transport with nerve compression of 20 mmHg[10,11].

Blood supply

Blood supply can be segmental, irrigating each fascicle with branches of the epineural vessels. The blood-nerve barriers are two diffusion barriers found in the perineurium and endoneurium. They provide the endoneurium with a homeostatic environment for uninterrupted axonal transport and conduction of the impulse generated by the nerve[12,13]. Mechanical compression can injure or damage these barriers, causing several pathophysiological, intraneural changes that impair nerve function. Nerve elongation of 8% will slow blood flow; a 15% elongation will result in complete cessation of intraneural blood flow. Blood flow will return depending on the severity of the hypoperfusion over a period of time[14,15].

Therapeutic interventions

Steroid injections

Local corticosteroid injections into the carpal tunnel have shown short-term efficacy in relieving symptoms of CTS. Improvements are generally observed within one month, particularly in patients with mild to moderate symptoms. However, long-term benefits remain unproven, and extreme caution is necessary to avoid inadvertent intraneural or intraarterial injections[16-18].

Tinel's sign

Tinel's sign is a test in which the examiner gently taps the anatomical location of the distal median nerve at the wrist crease. If tingling is felt in the fingers innervated by the median nerve, the test is considered positive. In 1915, Tinel et al. reported a tingling sensation upon tapping the injured nerve at a proximal stump, and it was speculated that this was a sign of axonal degeneration. The intention is to use this sign in patients after a closed traumatic injury to observe the nerve in its regenerative phase. Tinel's sign can be compromised, as it is not a precise test and can produce false negatives. Its effectiveness tends to be reduced in patients with carpal tunnel syndrome (CTS), where the nerves are continuously regenerating toward the distal wrist crease. The amount of pressure applied can also alter or limit the test[19].

Phalen test

This test is detectable once wrist flexion causes compression of the median nerve through the transverse carpal ligament and the flexor tendons of the carpal tunnel, producing paresthesia along the entire median nerve and causing the patient's symptoms. Phalen performed his test by asking the patient to hold their forearm vertically with their elbows resting on a table and then lower both hands with full wrist flexion over a period of

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one minute. Therefore, the test is considered positive when paresthesia occurs within one minute. However, patients with advanced carpal tunnel syndrome tend to experience paresthesia within 20 seconds[20].

5 CONCLUSION

Following the release of the nerve, patients had satisfactory surgical outcomes, including full remission of pain syndrome and no neurological decline beyond preoperative levels. After undergoing surgery, all patients were released in satisfactory health with a subjective improvement in hand sensitivity. Significant recovery was established by follow-up appointments one month after surgery, and local wounds healed by primary intention. Over the course of one to three weeks, and up to a maximum of one month, optimal postoperative care, including conservative management, was successfully implemented. The administration of conservative treatments and anti-inflammatory were follow up after months for standard consultation

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