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The AAOT Surgical Skills Center and Patient Safety

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One of the main problems detected in the training of resident physicians and, in general, in all those who take their first steps in a surgical specialty is the acquisition of skills, abilities, and techniques when such acquisition occurs directly in patient interventions, often through trial and error.

The teaching duty of experienced specialists is two-fold: to teach skills to colleagues in training while also protecting the patients entrusted to our care.

This is how learning techniques on simulated models emerged, whether synthetic or based on anatomical specimens from animals and humans. These methods make it possible to learn, apply and master the different stages of an operation (from surgical access to the actual technique) in order to successfully perform them on living human beings, reducing the likelihood of errors and iatrogenic injuries.

With these principles in mind, we set out to put them into effect after our Full Members elected me President of the AAOT in 2006. We first visited the BioSkills Lab at the AAOS Orthopedic Learning Center in Rosemont, Illinois, USA and consulted the specialized literature. Finally, we proposed the acquisition of a building for the aforementioned purposes, and the initiative was approved by the AAOT Members Assembly. This property, consisting of two adjacent units with a total area of 300 m2, in a building with a convenient location, was purchased at a price of USD 767 per m2, remodeled, and equipped with 6 work tables for dry and wet workshop practices and 2 tables for microsurgery practice, as well as zenithal lights and pipes under the floor with electrical wiring and other pipes connected, respectively, to a suction pump and a compressed air or nitrogen center. The piping was designed to connect arthroscopy suction and pneumatic cutting and drilling equipment. Following that, a high-resolution video camera was placed and connected to a large monitor. It was known as the Surgical Skills Center (SSC), and it was established by the Coordinating Committee for the Teaching of Surgical Skills. Article 1 of the SSC Regulations, incorporated into our Bylaws, states that its functions are "to promote all practical activities that allow the development of skills and abilities in surgical techniques and approaches in specialized post-graduate courses, as well as to constantly update and improve these techniques and approaches in the fields of orthopedics, traumatology, and related disciplines."

The Center is divided into two sectors that cover a total of 300 m2. Workstations, dressing rooms, and electrical and mechanical infrastructure are located in one, while an auditorium with a capacity of 40 people, restrooms, and offices are in the other.

The SSC went through several stages: a first stage from 2007 to 2010, under my direction; a second stage from 2011, under Dr. Adriana Pemoff's direction (when two freezers were purchased and several wet workshops were

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held); and a third stage from 2019 to the present. There was exponential growth during this last period, when I had the honor of directing the Center and chairing the Coordinating Committee.

From November 2019 to April 2024, 34 workshops were held, of which 6 were wet, with fresh anatomical specimens. Two of them were bovine and porcine and were held at the the SSC, while four were human and were held at the Buenos Aires, San Isidro and Bocalandro Clinical Hospitals. The first took place following the signing of a Cooperation Agreement with the Hospital (thanks to the cordial assistance of the directors Dr. Marcelo Melo and Dr. Andrés Ferrero), and the other two were possible thanks to the efforts of our current President, Dr. Carlos Autorino. Said workshops dealt with the following topics: Osteosynthesis in simulated model, Osteosynthesis in the elbow region, Osteosynthesis of the proximal humerus and diaphysis, External fixators and damage control in the lower limb, Practical principles in primary hip arthroplasty, Introduction to spinal trauma, and Basic surgical maneuvers in Orthopedics and Traumatology. A total of 958 orthopedists and 68 surgical technologists attended. In that period, at dollar value of each year, approximately USD 49,185 were collected from registrations. Approximately 25% was allocated to the purchase of equipment and instruments and 30% to the purchase of supplies for the workshops.

During this time, particularly under the direction of Drs. Olivetto, Varaona, and Autorino, the SSC was equipped with 8 surgical cubicles that included general and orthopedic surgery instruments (curettes, rasps, osteotomes, bone gouges, Hohmann retractors), a high resolution video camera, and, most recently, a new projector and zenithal LED lights for the work tables.

The activities were aimed especially at residents and specialists in training, with accessible fees and emphasis on "hands-on" activities, with as many boxes of implants as workstations with groups of 3-4 participants each, so that each one could execute the different steps of the technique in question. Previously, there was a theoretical update on the subject and a practical description of the corresponding exercise.

In our workshops, we attempt to fulfill the three stages of skill and ability acquisition (Fitts PM, Posner MI. Human performance. Belmont, CA: Brooks/Cole Publishing Company; 1967):

1. The cognitive stage, i.e., the understanding of what needs to be done.
2. The associative stage, i.e., learning to perform the skill.
3. The autonomous stage, i.e., when the skill becomes automatic.

In this way, a practical complement to the theoretical activities of the Triennial Specialization Course was developed, while adhering to the notion of acquiring abilities and skills prior to performing the corresponding techniques on patients.

I would like to highlight, in an undoubtedly incomplete enumeration, the disinterested participation in these activities of numerous teachers and instructors, including: for the Coordinating Committee, Andrés Del Valle, Guido Carabelli, Federico Burgo, Guillermo Ricciardi, Daniel Villena, Carlos Autorino, Federico Manfrin, Andrés Glasberg, and Julieta Porta; and for the Subcommittee, Hernán Aguilar, Pablo Buchuk, Federico Mori, Marcos Ávalos, Gabriel Morano, Martín González, Víctor García, Carlos Vega, Solange Ferraguti, and Micaela Besse. Additionally, Roque Nigro, Homero De Agostino, Hernán Barrachina, Daniel Algieri, Carlos Balbi and Oscar Zimman, among others, collaborated in teaching activities. Finally, Mrs. Natalia Morgani, the efficient secretary who tirelessly collaborated and organized the various events, deserves special recognition.

We would also like to thank the institutional and equipment support of the AAOT Board of Directors, successively presided by Dr. Carlos Sancineto, Dr. Miguel A. Ayerza, Dr. Andrés Silberman, Dr. Roberto Olivetto, Dr. José M. Varaona and Dr. Carlos Autorino.

However, this update would be incomplete unless we included future projects. In this regard, we believe that, in the near future, we may incorporate Microsurgical Orthoplasty workshops, expand the role of wet workshops, and equip the Center with operating table microscopes and, eventually, an image intensifier.

It is our intention to work together with the Continuing Medical Education Committee, in order to add the necessary practical complement to the intense work of theoretical training that the AAOT has been carrying out for decades.

Although the goal towards which we are walking may seem distant, perhaps the path we are on is more important.

As Antonio Machado said: "Traveler, there is no path, the path is made by walking."

Fingertip Injuries Treated with Semi-occlusive Dressings

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ABSTRACT

Objective: To demonstrate that semi-occlusive dressings achieve reconstruction of the distal phalanx with no residual pain, no additional shortening, and a satisfactory aesthetic appearance. **Materials and Methods:** 47 fingers with distal injuries were assessed and classified into three groups: a) with skin and subcutaneous cellular tissue involvement, b) with an additional nail injury, and c) with an additional open bone injury. All were covered with a semi-occlusive bandage which was replaced weekly until the wound healed, which took around four weeks. **Results:** 41 of the 47 treated fingers displayed excellent functional and aesthetic outcomes, with complete recovery of distal sensibility; nevertheless, 6 patients (14%) required additional surgery, all of whom had work conflicts. The average time for complete healing was 45.7 days, with three dressing replacements required to complete treatment. **Conclusion:** Fingertip injuries, even with the phalanx exposed, can be satisfactorily treated with semi-occlusive dressings. Reconstruction is achieved without residual pain, without additional shortening, with good strength and sensitivity, and with an excellent aesthetic appearance of the phalanx. It is also an economical and simple to replicate method.
Keywords: Fingertip injuries; distal amputation; semi-occlusive dressing.
Level of Evidence: IV

Lesiones de la punta de los dedos tratadas con apósito de sujeción intravenoso

RESUMEN

Objetivo: Demostrar que el vendaje semioclusivo logra una reconstrucción de la falange distal sin dolor residual, sin acortamiento adicional y con buen aspecto estético. **Materiales y Método:** Se evaluaron 47 dedos con lesiones distales que se dividieron en tres grupos: a) con compromiso de piel y tejido celular subcutáneo, b) con lesión adicional de la uña y c) con lesión ósea expuesta agregada. A todos se les colocó un vendaje semioclusivo con un recambio semanal hasta que la herida se curó, aproximadamente en cuatro semanas. **Resultados:** En 41 de los 47 dedos tratados, los resultados funcionales y estéticos fueron excelentes, con recuperación completa de la sensibilidad distal; 6 pacientes (14%) necesitaron una cirugía agregada, todos ellos en conflicto laboral. La media para la curación completa fue de 45.7 días y la media de recambio de apósito fue de tres en total para completar el tratamiento. **Conclusiones:** Las lesiones de la punta de los dedos, aun con la falange expuesta, pueden ser tratadas de forma satisfactoria con un vendaje semioclusivo, pues se logra una reconstrucción sin dolor residual, sin acortamiento agregado, con buena fuerza y sensibilidad, además con un excelente aspecto estético de la falange, es un método económico y fácil de reproducir.
Palabras clave: Amputación distal; dedo; vendaje semioclusivo.
Nivel de Evidencia: IV

INTRODUCTION

Fingertip injuries are those affecting the distal phalanx, distal to the terminal insertion of the flexor tendon and extensor tendon**,** with or without fracture. They account for 38% of the consultations for trauma in the upper limb.[1] There are many classifications to describe them, but none of them is widely used (Figure 1).[2] They usually leave associated sequelae, such as shortening, decreased mobility, sensation or strength. [3]

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In 1981, de Boer and Collison published a study in which they used an occlusive dressing with silver sulfadiazine on this type of wound, with which they obtained very good outcomes. These authors were interested in applying this technique to slightly more severe injuries involving loss of the pulp and terminal phalanx.[4]

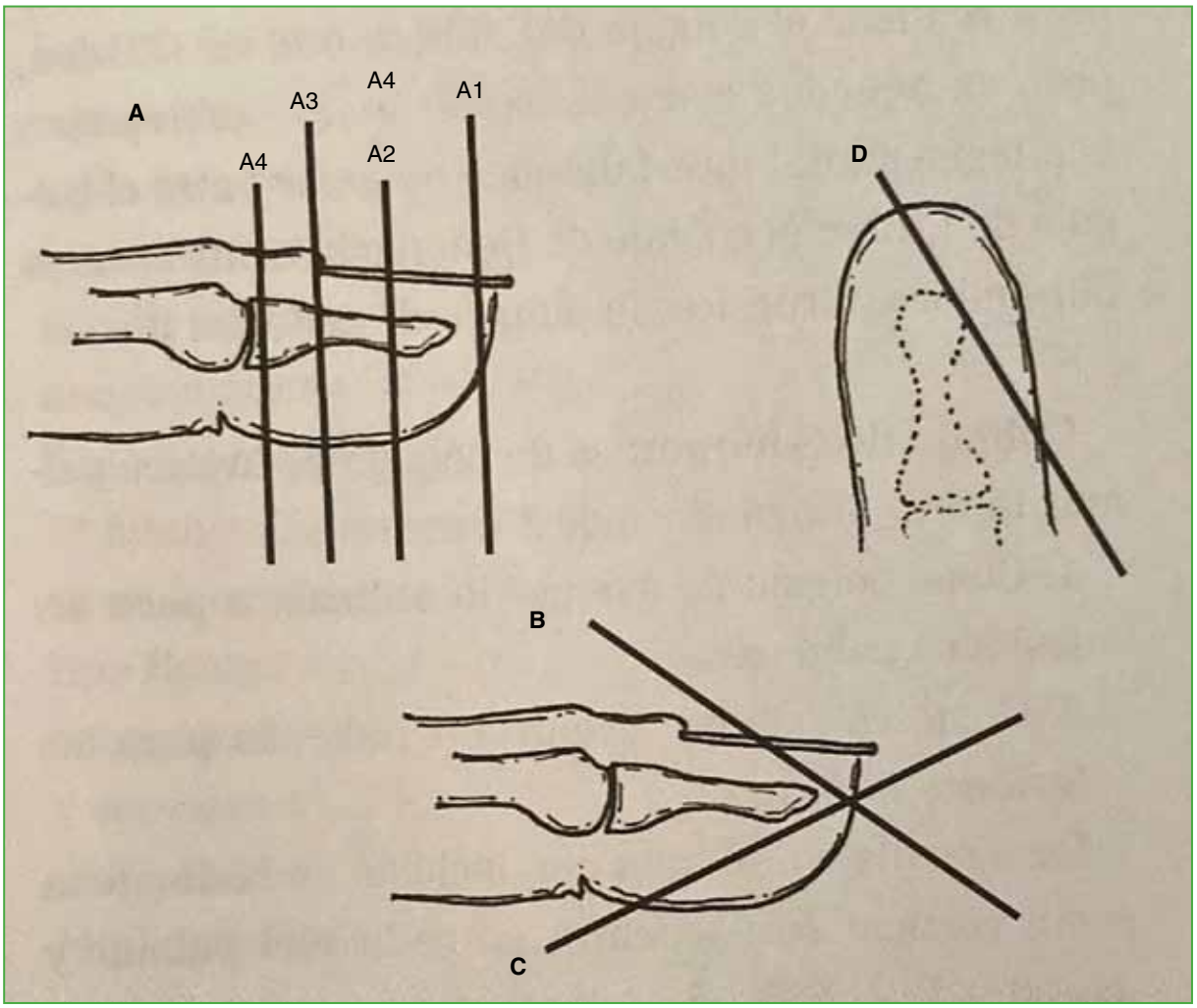

Figure 1. **A.** Right angle amputation: A1, distal without bone exposure; A2, through the nail bed; A3, proximal to the nail matrix; A4, proximal to the interphalangeal line. **B.** Dorsal angle amputation. **C.** Palmar angle amputation. **D.** Lateral angle amputation. Taken from citation 1.

Some time later, Mennen and Wiese began to use semi-occlusive dressings with a dressing whose original utility was to cover post-surgical wounds; later, other authors used 3M™ Tegaderm® for the same purpose, which was changed once a week and provided the wounds with a "temporary skin" that evolved into a painless injury, providing a medium apt to stimulate granulation and epithelization; the outcomes after 20 days of treatment were very satisfactory.[4,5]

This type of dressing generates an optimal environment in terms of pH value, temperature, and humidity, with growth factors and tissue hormones that accelerate healing and decrease scar formation in favor of local tissue regeneration.[6] The fluid that accumulates during healing resembles purulent secretion, but it is not. It may have an unpleasant odor, but this is not a reason to change the dressing, as this fluid influences the granulation that replaces the lost tissue (Figure 2).[7]

The purpose of this retrospective study was to demonstrate that semi-occlusive dressing of fingertip injuries, even with bone exposure, can result in a reconstruction with no residual pain, good sensitivity, no additional shortening, and a satisfactory aesthetic appearance.

Figure 2. Second change of the semi-occlusive dressing. The coverage of the exposed phalanx can be seen.

MATERIALS AND METHODS

We retrospectively evaluated a series of patients with fingertip injuries who were treated between 2016 and 2022 by the Upper Limb team of the Trauma Service (Table 1).

Table 1. Demographic data of the series.

Patient	Sex	Age	OAI-HI	Finger	Dominant hand		Mechanism of injury	Type of injury
1	M	30	OAI	Middle	No	Right	Blunt laceration	Nail involvement
2	M	48	OAI	Middle	No	Left	Crushing injury	Skin and SCT
				Ring	Yes	Left	Crushing injury	Skin and SCT
3	M	40	OAI	Index	No	Left	Crushing injury	Skin and SCT
				Middle	No	Left	Crushing injury	Skin and SCT
4	M	32	OAI	Middle	No	Left	Crushing injury	Bone involvement
5	M	27	OAI	Pinky	Yes	Right	Amputation	Bone involvement
6	M	30	OAI	Middle	Yes	Right	Blunt laceration	Skin and SCT
7	M	38	OAI	Middle	Yes	Right	Amputation	Bone involvement
				Ring	Yes	Right	Blunt laceration	Nail involvement
8	M	50	OAI	Index	Yes	Right	Blunt laceration	Nail involvement
9	M	39	OAI	Index	Yes	Left	Amputation	Bone involvement
				Middle	No	Left	Blunt laceration	Bone involvement
10	F	49	OAI	Index	No	Right	Blunt laceration	Bone involvement
11	M	40	OAI	Ring	Yes	Right	Sharp cut	Skin and SCT
12	M	39	OAI	Middle	No	Left	Blunt laceration	Blunt laceration
13	M	42	OAI	Index	Yes	Right	Blunt laceration	Bone involvement
14	M	50	OAI	Ring	Yes	Right	Amputation	Bone involvement
15	M	38	OAI	Index	Yes	Right	Blunt laceration	Bone involvement
16	M	17	HI	Middle	Yes	Right	Sharp cut	Skin and SCT
17	M	39	HI	Pinky	Yes	Right	Blunt laceration	Skin and SCT
18	F	32	HI	Pinky	No	Left	Amputation	Bone involvement
19	F	47	HI	Ring	Yes	Right	Sharp cut	Nail involvement
20	F	52	HI	Ring	Yes	Right	Sharp cut	Skin and SCT
21	M	47	HI	Index	No	Left	Blunt laceration	Nail involvement

M = male; F = female; OAI = occupational accident insurance; HI = health insurance; SCT = subcutaneous tissue.

All patients were treated by the same professional who used the same method and were included in the same group for the analysis of the results. All the patients gave informed consent for the proposed treatment.

Exclusion criteria were: 1) incomplete medical records or not meeting the necessary data for the study, 2) patients with injuries to the thumb, 3) patients with sprains of the distal phalanx of the finger.

The patients were divided into three groups according to Allen's classification for distal finger amputations:[8,9] a) patients with skin and subcutaneous tissue (SCT) involvement only, b) patients with additional nail involvement, c) patients with additional bone injury. A distinction was also made between those who suffered the injury as a result of an occupational accident and those who did not.

Description of the applied technique

The injured fingers were debrided and cleaned with saline and an antiseptic solution in the Emergency Department and a 3M™ Tegaderm® dressing was immediately applied (Figure 3). No antibiotics were administered. The dressing remained in place for seven days. After that time, it was changed in the outpatient clinic, cleaning the wound periphery with physiological saline, without debridement. The semi-occlusive dressing was then covered with gauze and adhesive tape. The procedure was repeated until the wound was healed. The patient was advised to make full use of the hand, including the finger under treatment.

The healing time was four weeks and required three dressing changes; the cost was USD 0.38 each (Source: MercadoLibre Argentina, box of 6 units of 3M™ Tegaderm® 6 x 7 cm).

The time necessary to achieve healing was calculated using the average and range of days passed from the beginning of treatment to medical discharge; patients discharged by physicians other than the investigator were not considered.

Regarding the presence of paresthesias and intolerance to cold after treatment, the patient's subjective expression or assessment was recorded, with two options: Yes or No.

The visual analog scale was used to document pain after treatment. In addition, the following variables were recorded and analyzed: a) sex: the absolute number and proportion of men and women are described, b) age: the age range of the sample is expressed, along with the average age plus or minus two standard errors, and the median with first and third quartiles, c) type of injury: the absolute values of injured fingers and hands are expressed; the type of injury is expressed in absolute value and proportion for each of the categories: injury only in skin and SCT equivalent to Allen's type C and D injuries; with additional nail involvement, equivalent to Allen's type B and D injury, and those with bone involvement, equivalent to Allen's type A injuries (Figure 1),[9] d) patients who suffered the injury in the work environment and patients who did not.

The mechanism of injury was expressed in absolute value and proportion for each of the categories: sharp cut, blunt laceration, amputation, and crushing injury.

To evaluate patient satisfaction with the treatment received and the outcome obtained, the patient's opinion was recorded during the satisfaction consultation, independently for each finger treated.

The proportion of patients who required surgery after dressing was calculated by dividing the number of patients who required surgery by the total number of patients included in the study.

Figure 3. Placement of the semi-occlusive dressing. Hemostasis can also be performed by manually compressing collaterals. In this case, local anesthesia was administered. Free spaces should be avoided during placement to prevent excessive fluid production.

RESULTS

Forty-one patients with 47 affected fingers were evaluated. In 15 fingers (32%), the injury involved only the skin and SCT, nine (19%) had additional nail involvement, and 23 had bone involvement.

Six of the 47 treated fingers (12.7%) required secondary surgery, all of these patients had sustained the injury in an occupational accident and all were male (Table 2).

Table 2. Levels of satisfaction

Patient	OAI-HI	Days of treatment	Additional surgery	Range of motion		Pa	VAS	Cold intolerance	Patient satisfaction
				DIP	PIP				
1	OAI	>70	Yes	Total	Total	No	2	No	Satisfied
2	OAI	51-60	No	Total	Total	No	0	No	Satisfied
		51-60	No	20°-60°	Total	No	0	No	Satisfied
3	OAI	51-60	No	Total	Total	No	0	No	Satisfied
		51-60	No	Total	Total	No	0	No	Satisfied
4	OAI	61-70	No	20°-60°	Total	No	2	No	Moderately satisfied
5	OAI	51-60	No	Blocked	>90°	No	0	No	Moderately satisfied
6	OAI	31-40	No	Total	Total	No	0	No	Satisfied
7	OAI	51-60	Yes	<20°	Total	No	0	No	Satisfied
		51-60	No	20°-60°	Total	No	0	No	Satisfied
8	OAI	>70	Yes	20°-60°	Total	No	8	No	Very satisfied
9	OAI	51-60	No	<20°	90°- 45°	No	0	No	Very satisfied
		51-60	No	20°-60°	90°- 45°	No	0	No	Satisfied
10	OAI	51-60	No	Total	Total	No	0	No	Satisfied
11	OAI	51-60	Yes	Total	Total	No	0	No	Very satisfied
12	OAI	>70	Yes	Total	Total	No	0	No	Satisfied
13	OAI	51-60	Yes	20°-60°	Total	No	0	No	Satisfied
14	OAI	51-60	No	Total	Total	No	3	No	Satisfied
15	OAI	51-60	No	20°-60°	Total	No	0	No	Satisfied
16	HI	31-40	No	Total	Total	No	0	No	Very satisfied
17	HI	41-50	No	20°-60°	Total	No	0	No	Very satisfied
18	HI	41-50	No	20°-60°	Total	No	0	No	Very satisfied
19	HI	31-40	No	Total	Total	No	0	No	Very satisfied
20	HI	31-40	No	Total	Total	No	0	No	Very satisfied
21	HI	31- 40	No	Total	Total	No	0	No	Very satisfied

OAI = occupational accident insurance; HI = health insurance; DIP = distal interphalangeal joint; PIP = proximal interphalangeal joint; Pa = paresthesia; VAS = visual analog scale for pain.

No differences in average age or mechanism of injury production were found in the study population.

Discharge was considered between day 30 and 211 (mean 45.7 days; median 35.5 days), depending on the severity of the injury; patients who had had an occupational accident required the longest time for healing.[1]

The mean number of dressings required for complete treatment was 3.42 (range 2-5).

Distal interphalangeal range of motion in the treated finger after treatment was: total in 44 (93.6%) of the treated fingers; between 90° and 45° in two (4.25%) fingers, and >90° in one finger (2.12%). No mobility blocks were observed (Table 2).

No patient had paresthesia in the treated finger after treatment.

Thirty-five (84%) did not suffer pain after treatment; six (15%) did: three had mild pain (visual analog scale between 2 and 3), and one had severe pain (visual analog scale 8).

None reported cold intolerance in the treated finger after treatment.

Twenty-nine (62%) were very satisfied with the treatment and with the aesthetic outcome; 16 (34%) were satisfied; and two (4.25%) were moderately satisfied.

When asked if they would undergo the same treatment, all said yes (Figure 4).

Figure 4. Final outcome in patients treated with semi-occlusive dressings.

DISCUSSION

The semi-occlusive bandage-directed healing method, which uses a 3M™ Tegaderm® IV securement dressing, is very simple and can be considered as a suitable treatment for fingertip injuries, even those with bone exposure.[6,7]

Although it has not been evaluated for this purpose, it has the advantage of creating a bed that stimulates healing while avoiding excessive skin maceration and facilitating painless recovery. It is transparent, so it is visible to the patient for consultation if he or she has any concerns, water resistant (though it is recommended not to get wet), and serves as an antibacterial barrier. This material additionally provides a higher rate of moisture transmission,[10] which is why it is known as a semi-occlusive bandage.

There are numerous treatments available, ranging from primary or secondary wound closure to free skin grafting, local or delayed flaps; however, none of these quickly restore sensation to the defect area.[6]

According to Mühldorfer-Fodor et al. and Ha et al., utilizing a semi-occlusive dressing for this purpose results in a higher-quality epithelial cover, even when the thumb of the finger is reconstructed using plastic surgery. Tactile discrimination in these patients after three months indicates a return to normal levels.[7]

The soft tissue cover is reinserted over the distal phalanx even if it is exposed (Figure 2); the reconstruction that takes place with this method is such that the nail matrix grows in a more natural way, reducing the appearance of deformed nails.[4,6,7,10]

Our findings are consistent with those of previous studies; it was demonstrated that this treatment achieves the expected goal of treating fingertip injuries, which is to achieve reconstruction without residual pain, with the greatest possible length and mobility, as well as a more than acceptable cosmetic outcome.

One of the described complications of this method, which discourages its use, is the odor produced during the healing process, which was not often reported by our patients.[5,11] New materials have been reported that accomplish the same purpose but increase cost.[12]

CONCLUSIONS

Our study demonstrated that patients with fingertip wounds treated with semi-occlusive, intravenous securement dressings obtain excellent aesthetic and functional outcomes, even in wounds with bone exposure. Treatment is completed with no residual pain, no additional shortening, adequate sensitivity and, in the vast majority of cases, without further interventions.

This treatment was shown to be economical, simple and a valid alternative to other more complex types of reconstruction for fingertip injuries.

We believe that its strength stems from the consistent treatment and evolution of patients provided by the same professional, as well as the sample's homogeneity and patient follow-up period based on the condition treated.

Weaknesses include the retrospective evaluation and the sample size, which could be larger, but given the population of the region, we believe it is significant.

Conflict of interest: The author declares no conflicts of interest.

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Effectiveness of the Six-Item Carpal Tunnel Symptoms Scale (CTS-6) Questionnaire for the Diagnosis of Carpal Tunnel Syndrome

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ABSTRACT

Introduction: The Six-Item Carpal Tunnel Symptoms Scale (CTS-6) is a a short 6-item scale based on the Boston Carpal Tunnel Questionnaire (BCTQ). **Objective:** To evaluate the CTS-6 to identify patients with peripheral neuropathy of the median nerve using surgical criteria. **Materials and Methods:** A prospective descriptive observational study was conducted on a group of patients diagnosed with carpal tunnel syndrome. The CTS-6 was employed, and the diagnosis was confirmed with electromyography. The patients then underwent surgery. The differences in the CTS-6 score between the various severity levels measured by electromyography were examined. **Results:** 106 patients were analyzed and a total of 126 hands were evaluated. 20.75% had bilateral carpal tunnel syndrome. The median CTS-6 score was 21 (min. 16.5; max. 26). According to electromyography results, 24.22% of CTS cases were severe. When comparing the CTS-6 score according to the severity of carpal tunnel syndrome assessed by electromyography, the median CTS-6 score was 16.5 in mild cases, 21 in moderate cases, and 26 in severe cases. **Conclusions:** Electromyography revealed a higher CTS-6 score in patients with severe carpal tunnel syndrome. This raises the possibility that it could be used as a noninvasive diagnostic tool in carpal tunnel syndrome to determine which patients would benefit from surgical therapy.

Keywords: Carpal tunnel syndrome; CTS-6 scale; carpal tunnel release; electromyography.
Level of Evidence: IV

Efectividad de la *Six-Item Carpal Tunnel Symptoms Scale* para el diagnóstico del síndrome del túnel carpiano

RESUMEN

Introducción: A partir del *Boston Carpal Tunnel Questionnaire* (BCTQ), se desarrolló una escala corta de 6 ítems llamada *Six-Item Carpal Tunnel Simptoms Scale* (CTS-6). **Objetivo:** Evaluar la CTS-6 para detectar pacientes con neuropatía periférica del nervio mediano con criterio quirúrgico. **Materiales y Métodos**: Se realizó un estudio descriptivo prospectivo observacional en un grupo de pacientes con diagnóstico clínico de síndrome del túnel carpiano. Se utilizó la CTS-6, y se corroboró el diagnóstico mediante electromiografía. Posteriormente, los pacientes fueron operados. Se analizaron las diferencias en el puntaje de la CTS-6 entre los distintos niveles de gravedad determinados por electromiografía. **Resultados:** Se analizaron 106 pacientes. El 20,75% tenía síndrome del túnel carpiano bilateral. Se evaluaron 126 manos. La mediana del puntaje de la CTS-6 fue de 21 (mín. 16,5; máx. 26). Según los resultados de la electromiografía, el 24,22% de los casos de STC eran graves. Al comparar el puntaje de la CTS-6 según la gravedad del síndrome del túnel carpiano evaluada por electromiografía, la mediana del puntaje de la CTS-6 fue de 16,5 en los casos leves, de 21 en los casos moderados y de 26 en los casos graves. **Conclusiones**: El puntaje de la CTS-6 fue mayor en los pacientes con síndrome del túnel carpiano grave según la electromiografía. Esto plantea la hipótesis de que podría ser útil como herramienta diagnóstica no invasiva en el síndrome del túnel carpiano para definir pacientes que se beneficien con el tratamiento quirúrgico.

Palabras clave: Síndrome del túnel carpiano; escala de síntomas CTS-6; liberación del túnel carpiano; electromiografía.
Nivel de Evidencia: IV

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INTRODUCTION

Carpal tunnel syndrome (CTS) is a common compressive neuropathy with an estimated prevalence of 6% in men and 9.2% in women.[1] It is characterized by an initial clinical picture of pain, numbness and paresthesias in the thumb, index, middle and radial side of the ring finger that can lead to hand weakness, decreased fine motor coordination and thenar atrophy.[2] It is diagnosed clinically by anamnesis and physical examination, and is usually confirmed by nerve conduction studies such as electromyography.

Within the range of diagnostic possibilities, multiple clinical scales have been implemented, such as the *Boston Carpal Tunnel Questionnaire* (BCTQ), developed in 1993, to assess median nerve symptoms and functional impairment.[3] The BCTQ consists of a symptom severity scale with 11 items that assess pain, paresthesias, numbness, weakness, nocturnal symptoms, and difficulty with grip, as well as a functional status scale containing 8 items that assess functional deficits in the following domains: writing, buttoning clothes, holding a book while reading, gripping a telephone handle, opening jars, performing household chores, carrying a grocery basket, bathing and dressing.

Atroshi et al. have developed a short version of the BCTQ symptom scale which they called the *Six-Item Carpal Tunnel Symptoms Scale* (CTS-6). The CTS-6 contains 6 items measuring the severity and frequency of numbness and tingling, as well as nighttime and daytime pain,[4] with scores ranging from 0 to 26. If a patient has a score ≥12 and CTS is clinically suspected, it is not recommended to perform median nerve conduction electromyography to confirm or rule out the diagnosis, as the probability of a positive diagnosis is 80%. However, a score between 12 and 5 decreases the probability to 25%, so the study is recommended.[5]

Electromyography measures focal nerve demyelination, and is considered the gold standard for diagnosis. A drawback of this diagnostic method is the discomfort for the patient, because needles are introduced at the subcutaneous level and the sensation produced by the electricity during measurements is often described as uncomfortable. At present, it has not been replaced by less invasive methods, as detailed in various publications that attempted to compare it to ultrasonography or nerve conduction studies with electrodes.[6]

Today, the decision to initiate treatment is based on the severity of symptoms and the results of electromyography. Generally, nocturnal immobilization of the wrist is recommended if CTS is mild and surgery (median nerve release by dissection of the transverse carpal ligament) is chosen in moderate and severe cases, and mild cases that do not respond to non-surgical management.[7]

However, in view of the 16% to 34% false-negative rates obtained in various series, electromyography cannot be considered as a reference study for the diagnosis of CTS.[8] Furthermore, it has been independently demonstrated that electromyography does not provide additional information, nor does it change clinical outcomes after carpal tunnel decompression surgery to a clinically relevant extent. [9]

The aim of this study was to evaluate the use of CTS-6 to detect patients with surgical criteria for peripheral neuropathy of the median nerve. The findings could provide evidence to reduce the use of electromyography while also allowing health professionals to identify patients who could benefit from surgical treatment in a simple and minimally invasive manner.

MATERIALS AND METHODS

This study was approved by the institution's Research Ethics Committee.

A prospective descriptive observational study was conducted in a group of patients with a clinical diagnosis of CTS, who attended the Outpatient Clinic of our institution, between February 2019 and July 2022. Patients >18 years old with suspected CTS, who gave their consent to participate in the study, were consecutively included. Pregnant women, patients operated on for CTS, with a history of fractures in the wrist region or with other associated neuropathy were excluded.

A variant of the CTS-6 (Table 1), in its Spanish translation, was used.[10] The CTS-6 was used during the first medical consultation with the upper limb specialist after recording the symptoms and the findings of the physical examination, together with the two-point discrimination test, and then the patient was asked to undergo electromyography to corroborate the diagnosis. Given the observed high sensitivity and specificity, a CTS-6 cutoff point >12 was established.[5]

Table 1. Six-Item Carpal Tunnel Symptoms Scale (CTS-6).

CTS-6 component	Description	Score
Numbness in the median nerve territory	Sensory symptoms are mostly in the thumb, index, middle or ring finger.	3.5
Nocturnal numbness	Symptoms are prominent when the patient sleeps, and numbness awakens the patient.	4
Thenar atrophy or weakness	Most of the thenar area is reduced or the manual motor test shows a strength of grade 4 or less.	5
Positive Phalen's test	Wrist flexion reproduces or worsens numbness symptoms in the median nerve territory.	5
Loss of 2-point discrimination	A failure to discriminate 2 points held 5 mm or less apart on fingers innervated by the median nerve is a positive test suggestive of CTS.	4.5
Positive Tinel sign	Light tapping over the median nerve at the level of the carpal tunnel causing paresthesia radiating to the fingers innervated by the median nerve (not proximally) is a positive test.	4

Electromyography was performed in the same facility to avoid bias, as it is an operator-dependent study. CTS was classified into mild, moderate and severe stages based on the severity of median nerve demyelination, according to the Padua classification:[11] mild (compromised sensory conduction velocity >0.8 ms), moderate (compromised sensory conduction velocity and motor latency >1.5 ms) and severe (no sensory conduction velocity and prolonged motor latency).

The patients were then operated on using the same surgical approach by different resident surgeons under the supervision of specialists in Traumatology and Hand Surgery. Following surgery, the wound was covered with soft bandages, and patients were given oral and written instructions on postoperative exercises and a gradual return to activity.

Statistical analysis

The sample was described with measures of central tendency and dispersion for continuous numerical variables and percentage for categorical variables. The sample was described over the total number of patients and the results over the total number of hands evaluated. Comparison of the CTS-6 results between severity levels assessed with electromyography was performed using the Kruskall-Wallis test. Statistical analysis and calculations were performed with the SPSS version 22 program with an authorized license. A p value <0.05 was considered statistically significant.

RESULTS

A total of 106 patients were analyzed, the average age was 64.90 years (min 13, max 82). 20.75% (n = 22) had bilateral CTS (Table 2) and 76.42% of the sample were women. There was a slight increase in right over left hand involvement, and 22% had bilateral involvement.

In total, 128 hands were evaluated, and the mean score of the questionnaire was 21. In general, all had typical symptoms, such as numbness, nocturnal paresthesias, and positive Tinel and Phalen signs (Table 3). Only 26% (34 hands) had thenar atrophy. The two-point discrimination test yielded an altered result in 120 patients.

The electromyography results indicated a mostly moderate stage (69%). A correlation was observed between these findings and the questionnaire score, since, in patients with a test indicating a mild stage, the score was, on average, 16; for moderate cases, the average was 21; and severe cases reached the maximum score of 26 (Table 3), which represent statistically significant values.

In the comparison of CTS-6 score and CTS severity assessed with electromyography, a higher CTS-6 score was observed in cases with higher severity (Table 4).

Table 2. Description of the sample.

	Total (n = 106)
Age, years, mean (SD)	64.90 (13.82)
Sex, n (%) Male Female	 25 (23.58) 81 (76.42)
Laterality,* n (%) Left Right Bilateral	 41 (38.67) 43 (40.56) 22 (20.75)

SD = standard deviation. *A total of 128 median nerves were evaluated in 106 patients.

Table 3. Description of results.

	Total hands (n =128)
CTS-6 score, mean (IQR)	21 (21-26)
Symptoms, n (%) Numbness Nocturnal symptoms Positive Phalen's test Positive Tinel sign Loss of 2-point discrimination Thenar atrophy	 128 (100) 128 (100) 128 (100) 128 (100) 120 (93.75) 34 (26.56)
Electromyography, n (%) Mild stage Moderate stage Severe stage	 8 (6.25) 89 (69.53) 31 (24.22)

CTS = Six-Item Carpal Tunnel Symptoms Scale; IQR = interquartile range.

Table 4. Comparison of CTS-6 assessment and electromyography results.

	Total	Mild	Moderate	Severe	p
CTS-6 score, median (range)*	21 (16.5-26)	16.5 (16.5)	21 (21-26)	26 (26)	0.0001

CTS-6 = *Six-Item Carpal Tunnel Symptoms Scale*. *Median and ranges reported on a total of 128 hands.

DISCUSSION

CTS is the most prevalent compressive neuropathy, and while electromyographic studies are the most reliable diagnostic tool, it should be noted that the diagnosis is primarily dependent on anamnesis and clinical symptoms. Furthermore, it has been shown that routine electrodiagnostic testing has low sensitivity and specificity for mild CTS. Clinical and neurophysiological dissociation are frequently observed. Patients with a mild or moderate stage according to electromyography have normal hand function but may become severely symptomatic, whereas severe CTS has severely reduced hand function and milder symptoms. This suggests that the patient's point of view is reliable. Even if only minor electrophysiological abnormalities or functional impairments are observed, a sizable proportion of the CTS population experiences significant symptoms in the early stages of nerve impairment. The CTS-6 is a subjective measure, and assesses symptoms and function from the patient's point of view. It determines function and symptoms in patients with CTS through questions related to numbness and tingling sensation, pain, and functional status.[12]

Often, there is a discrepancy between the severity of CTS as reported by the patient and the clinical assessment of the physicians. As the treatment protocol to be applied in CTS is connected to the severity of compression, the study findings revealed a statistically significant relationship between CTS-6 and nerve conduction study results.[13] It was observed that the scores of patients with normal electromyography were very close to those of patients with mild CTS. Moreover, the scores were higher as the severity of compression increased. Based on these findings, we believe that the use of CTS-6 can provide insight into the severity of compression more effectively, rather than assessing symptoms separately.

When evaluating the relationship between CTS-6 and electromyography for the detection of patients with CTS who are candidates for surgery, the CTS-6 score was higher when electromyography indicated greater severity. This raises the hypothesis that CTS-6 could be useful as a noninvasive diagnostic tool in CTS. Grandizio et al.[14] obtained similar results and suggest that CTS-6 can also be used reliably as a screening and diagnostic tool for CTS by physicians without specific training in upper limb surgery. [15]

When CTS-6 was used for the mildest symptoms of CTS, such as numbness of the fingers, nocturnal symptoms, and positive Tinel and Phalen signs, the symptoms were positive in all cases. Two-point discrimination loss was seen in patients with predominantly moderate and severe stages according to electromyography; however, only patients with severe stages had thenar atrophy. Likewise, Levine et al. found an insignificant correlation between median sensory nerve conduction velocity and the overall symptom severity scale in CTS. Furthermore, they suggested that symptom severity cannot be estimated by measuring nerve conduction.[3] Ortiz-Corredor et al.[16] argued that numbness and tingling questions in clinical questionnaires, such as the BCTQ, better reflect the pathophysiology of the median nerve and have a strong and direct statistical correlation with distal sensory and motor latencies of the median nerve and, therefore, may be more useful in the diagnosis, follow-up, and evaluation of therapeutic outcomes in CTS. De la Llave-Rincón et al.[17] found no significant differences in pain parameters between patients with mild, moderate and severe CTS. They suggested that increased pain sensitivity is not related to electrodiagnostic findings or to the presence of unilateral or bilateral symptoms in patients with mild, moderate or severe CTS. CTS involves not only central sensitization (spinal or supraspinal mechanisms) but also peripheral sensitization (afferent impulse from the median nerve). Even if symptoms originate primarily above the median nerve distributions, 50% of patients with CTS experience extramedian sensory symptoms resulting in total hand involvement and proximal pain in the forearm, arm, and shoulder, indicating central sensitization. Central sensitization provides a pathophysiologic explanation for patients with CTS who experience persistent symptoms despite surgical treatment.

Although sensory symptoms are the main problem in CTS, patients often report motor symptoms, such as hand weakness and difficulty grasping small objects. Conventional motor conduction studies may not be sensitive enough to define motor axon abnormality, particularly in mild to moderate CTS. There is a discrepancy between motor symptoms and measures of motor function, even if median nerve motor conduction and motor examination are normal. Pain may be a factor in explaining this discrepancy. Chronic pain can alter the function of the motor control system and influence motor performance through a variety of mechanisms. Tamburin et al.[18] indicated that hand weakness and clumsiness can be detected in 56% and 48% of hands with CTS, respectively. They also demonstrated that hand weakness was related to the severity of sensory symptoms (pain, numbness and tingling), but not to clinical-electrophysiological measures of median nerve involvement, whereas hand clumsiness was subjugated to the severity of sensory symptoms and clinical-electrophysiological measures of median nerve motor damage, but not sensory damage.

The variability between symptoms and nerve conduction study findings suggests that the decrease in nerve conduction threshold required for symptom production varies from person to person.[19] The diagnosis of CTS should be evaluated not only as an electrodiagnostic finding, but also as a whole, depending on the patients' clinical picture. When there are no electrodiagnostic abnormalities and the patient exhibits clinical symptoms and CTS findings on physical examination, the patient can be diagnosed with CTS and treated accordingly. It becomes apparent that evaluating clinical sensory symptoms rather than motor symptoms is a useful tool in the diagnosis of CTS. Ultimately, the correct diagnosis is critical in determining the most effective treatment plan and prognosis.

Regarding the medicolegal issues that may arise as a result of avoiding electromyography, we will refer to the levels of evidence published in the *American Academy of Orthopaedic Surgeons Evidence-Based Clinical Practice Guideline on: Management of Carpal Tunnel Syndrome-2016.*[20] This publication shows that there is limited 2/5 evidence to support that nerve conduction studies could be used for the diagnosis of CTS. In contrast, diagnostic scales (and specifically CTS-6) had a moderate 3/5 evidence. Although some articles[8] suggest that, given the reported evidence of 16% to 34% false negative rates in various series, electromyography should not be used as a reference study for the diagnosis of CTS, our study found a correlation between the severity determined by the questionnaire and the severity determined by electromyography. Based on the analysis of the literature, the evidence showed that changes in probability after electrodiagnostic testing, using any of the electrodiagnostic definitions, were minimal and most likely less than a clinically relevant standard. This suggests that the most appropriate setting for electrodiagnostic testing is one in which there is uncertainty about the clinical diagnosis.

CONCLUSIONS

The CTS-6 can provide a standardized measure of symptom severity and functional status in patients with CTS. It can be used as a supportive tool for the diagnosis and treatment of CTS in this population, as well as to measure the clinical severity of symptoms and predict potential therapeutic behavior.

More studies with higher methodological quality and a larger sample size are required to generate evidence to support the use of CTS-6 in detecting patients who are candidates for CTS surgery.

Conflict of interest: The authors declare no conflicts of interest.

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A New Physical Diagnostic Tool for the Diagnosis of De Quervain's Tenosynovitis: First Compartment Synergy Test

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ABSTRACT

Introduction: There are two main provocative tests that can help us identify De Quervain's tenosynovitis. These are better known as the Finkelstein and Eichhoff tests. Both maneuvers are passive and attempt to elongate the affected tendons. Following the notion of muscle synergy, we decided to describe a new active maneuver for diagnosing De Quervain's tenosynovitis, thus incorporating a new physical diagnostic tool for a more precise diagnosis. **Materials and Methods:** A prospective study was conducted, evaluating all skeletally mature patients who presented with mechanical pain on the radial border of the wrist between April and July 2023. Tests for De Quervain's tenosynovitis were performed, as well as assessments for other radial border diseases. Diagnostic imaging studies were requested to confirm the diagnosis. The specificity and sensitivity of the physical tests were determined. **Results:** A total of 38 patients were included, and 43 wrists were evaluated (29 females, 9 males). The average age was 47 years. The sensitivity and specificity of the synergy test were 94.87% and 100%, respectively, with a positive predictive value of 100%. **Conclusion:** The findings reveal that active maneuvers outperform passive maneuvers for reaching the correct diagnosis; in this case, the proposed synergy test is the most specific. However, this maneuver should not replace existing ones.
Keywords: De Quervain's tenosynovitis; physical diagnosis; first dorsal compartment; synergy test.
Level of Evidence: II

Nueva herramienta semiológica para el diagnóstico de la tendinitis de De Quervain: prueba de sinergia del primer compartimento

RESUMEN

Introducción: Existen dos maniobras de provocación principales que pueden ayudar a identificar una tenosinovitis de De Quervain, más reconocidas como prueba de Finkelstein y prueba de Eichhoff. Ambas maniobras son pasivas buscando la elongación de los tendones comprometidos. Siguiendo el principio de sinergia muscular, decidimos describir una nueva maniobra activa que permita diagnosticar la tendinitis de De Quervain y así incorporar una nueva herramienta semiológica para llegar a un diagnóstico más preciso. **Materiales y Métodos:** Se realizó un estudio prospectivo que evaluó a todos los pacientes esqueléticamente maduros que acudieron con dolor mecánico en el borde radial de la muñeca entre abril y julio de 2023. Se les realizaron las maniobras para tendinitis de De Quervain, así como para otros cuadros del borde radial, y se solicitaron estudios diagnósticos por imágenes para confirmar la enfermedad. Se determinó la especificidad y sensibilidad de las pruebas semiológicas. **Resultados:** Se incluyó a 38 pacientes (43 muñecas), 29 mujeres y 9 hombres. El promedio de edad era de 47 años. La sensibilidad y especificidad de la prueba de sinergia fueron del 94,87% y 100%, respectivamente, con un valor predictivo positivo del 100%. **Conclusiones:** Los resultados obtenidos demuestran que las maniobras activas son superiores a las pasivas para llegar al diagnóstico correcto; en este caso, la prueba de sinergia propuesta fue la más específica. Esta maniobra no debería reemplazar a las existentes.
Palabras clave: Tendinitis de De Quervain; tendinitis del primer compartimento; extensor de muñeca; semiología; prueba de sinergia.
Nivel de Evidencia: II

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INTRODUCTION

De Quervain's tenosynovitis is a common and frequent condition of the first extensor compartment of the wrist. It mainly affects manual workers and, to a greater extent, the female gender in a 4:1 ratio, with a peak incidence at the age of 40.[1]

The osteofibrous tunnel that forms the first extensor compartment of the wrist, located at the level of the radial styloid, has an average length of 2 cm and contains the tendons of the extensor pollicis brevis and abductor pollicis longus, with different anatomical variants.[2]

Many diagnostic techniques have been described for this syndrome, which can be divided into two categories: passive maneuvers, the most well-known of which are the Finkelstein and Eichhoff tests, and active maneuvers, which include the wrist hyperflexion and abduction of the thumb (WHAT) test.[3,4]

Following the principle of muscle synergy and taking into account the work of Ruland and Hogan on the extensor carpi ulnaris [ECU] synergy test,[5] we decided to describe a new active maneuver to diagnose de Quervain's tendinitis and thus incorporate a physical diagnosis tool that, together with those previously described, allows for a more precise diagnosis.

MATERIALS AND METHODS

An analytical, descriptive, prospective study was conducted between April and July 2023, in which all patients with mechanical pain over the first extensor compartment of the wrist were evaluated.

Skeletally mature patients (>16 years old) with pain in the first extensor compartment were included. All underwent four physical tests for the diagnosis of de Quervain's tendinitis (Finkelstein, Eichhoff and WHAT) including the test described in this article. In addition, the patients were tested for further disorders that cause radial border pain, including trapeziometacarpal or scaphotrapeziotrapezoid osteoarthritis, ligament instabilities, tumors, and compressive neuropathies.

Patients with previous surgery on the radial border of the wrist and those who had been treated with injections were excluded.

The synergy test is performed with the patient seated, the elbow resting on the table and flexed at 90°, and the forearm and wrist in the neutral position. The patient is asked to spread the fingers apart without resistance, which may cause pain over the first compartment. Resistance is then applied by using the second and fifth fingers to exert the opposite force as the patient. Palpation reveals the contraction of the wrist-stabilizing muscles (Figure). A test is considered positive if the person feels pain in the first dorsal compartment of the wrist or immediately distal to it during finger separation or during the application of resistance.

All patients underwent anteroposterior and lateral radiographs of the affected wrist; additionally, depending on the case, an MRI or ultrasound was requested to confirm or rule out the diagnosis of de Quervain's tendinitis. The request for one or the other study was left to the choice of each physician.

Figure. Synergy maneuver of the first extensor compartment of the wrist.

Demographic data, such as age and gender, and clinical data, such as affected hand, positive and negative tests, and studies ordered to diagnose the evaluated disease, were gathered (Table 1).

Table 1. Patient data.

Hand evaluated	Age	Gender	Affected hand	Finkelstein test	Eichhoff test	WHAT Test	Synergy	Diagnostic imaging
1	57	M	Left	Positive	Positive	Positive	Positive	Positive
2	51	F	Right	Negative	Positive	Positive	Positive	Positive
3	37	F	Right	Positive	Positive	Positive	Positive	Positive
4	43	F	Right	Positive	Positive	Negative	Positive	Positive
5	33	F	Right	Positive	Positive	Negative	Negative	Scapholunate instability
6	52	F	Right	Positive	Positive	Positive	Positive	Positive
7	67	F	Right	Positive	Positive	Positive	Negative	Trapeziometacarpal osteoarthritis
8	54	M	Left	Negative	Positive	Positive	Positive	Positive
9	31	F	Right	Negative	Negative	Positive	Positive	Positive
10	31	F	Left	Negative	Positive	Positive	Positive	Positive
11	29	F	Left	Negative	Positive	Positive	Positive	Positive
12	54	F	Right	Positive	Positive	Positive	Positive	Positive
13	44	F	Left	Negative	Negative	Positive	Positive	Positive
14	52	F	Left	Positive	Positive	Positive	Positive	Positive
15	63	F	Left	Positive	Positive	Negative	Negative	Trapeziometacarpal osteoarthritis
16	63	F	Right	Negative	Positive	Positive	Positive	Positive
17	65	M	Right	Negative	Positive	Positive	Positive	Positive
18	39	F	Left	Negative	Positive	Positive	Positive	Positive
19	39	F	Right	Positive	Positive	Positive	Positive	Positive
20	40	F	Left	Negative	Negative	Positive	Positive	Positive
21	40	F	Right	Negative	Positive	Positive	Positive	Positive
22	40	F	Left	Positive	Positive	Positive	Positive	Positive
23	40	F	Right	Positive	Positive	Positive	Positive	Positive
24	48	F	Right	Negative	Positive	Positive	Positive	Positive
25	54	F	Right	Negative	Positive	Positive	Positive	Positive
26	38	F	Left	Negative	Negative	Positive	Positive	Positive
27	38	F	Right	Negative	Positive	Positive	Positive	Positive
28	28	M	Left	Negative	Positive	Positive	Positive	Positive
29	58	M	Left	Negative	Positive	Positive	Positive	Positive
30	41	F	Right	Negative	Positive	Positive	Positive	Positive
31	69	F	Right	Positive	Positive	Positive	Positive	Positive
32	56	F	Right	Negative	Positive	Positive	Positive	Positive
33	23	M	Right	Positive	Positive	Positive	Positive	Positive
34	49	F	Right	Negative	Positive	Negative	Positive	Positive
35	64	F	Right	Positive	Negative	Negative	Negative	Trapeziometacarpal osteoarthritis
36	24	M	Right	Positive	Positive	Positive	Positive	Positive
37	30	F	Right	Negative	Negative	Positive	Negative	Positive
38	70	F	Left	Negative	Negative	Positive	Positive	Positive
39	49	M	Right	Negative	Negative	Positive	Negative	Positive
40	55	F	Right	Positive	Negative	Positive	Positive	Positive
41	54	M	Left	Negative	Negative	Positive	Positive	Positive
42	65	F	Left	Negative	Positive	Positive	Positive	Positive
43	54	F	Left	Positive	Positive	Positive	Positive	Positive

M = male; F = female; WHAT = wrist hyperflexion and abduction of the thumb.

The sensitivity and specificity of each of the physical tests for De Quervain's tendinitis were calculated using IBM SPSS Statics 29.0 software and compared to the synergy test results. A p-value ≤0.05 was considered statistically significant.

This study was approved by the institution's Ethics and Research Committee.

RESULTS

Thirty-eight patients were included with a total of 43 wrists evaluated (5 with bilateral disease). Twenty-nine (76.31%) were women and nine (23.68%) were men, with a mean age of 47 years (range 23-70).

In four of the 43 wrists, disease was ruled out by physical and imaging studies. One patient had scapholunate ligament instability, as evidenced by a positive MRI for scapholunate injury, positive scapholunate ligament stability maneuvers, and positive Finkelstein and Eichhoff tests, but the WHAT and synergy tests were negative. In the remaining three wrists, trapeziometacarpal osteoarthritis was diagnosed by physical maneuvers and confirmed by radiographs. All three patients had positive Finkelstein and Eichhoff tests and only one, a positive WHAT test, while the synergy test was negative in all three cases. To rule out the presence of both entities in the same wrist (trapeziometacarpal osteoarthritis plus De Quervain's tendinitis), ultrasound and MRI scans were requested, which were negative in both cases.

The sensitivity and specificity of the synergy test were 94.87% and 100%, respectively, with a positive predictive value of 100%. The results of the remaining maneuvers are shown in Table 2.

Table 2. Calculated values for each maneuver.

Maneuver	Sensitivity	Specificity
Synergy	0.9487	1
WHAT	0.9487	0.7500
Eichhoff	0.7692	0.2500
Finkelstein	0.3333	0.0000

WHAT = wrist hyperflexion and abduction of the thumb.

When comparing the synergy test with the passive tests (Finkelstein and Eichhoff), it was observed that the specificity of this active test is statistically superior for the diagnosis of the disease. However, no differences were found between the WHAT test and the synergy test (Tables 3 and 4).

Table 3. Comparison of the maneuvers with the synergy test.

Comparison	Sensitivity p	Specificity p
Synergy vs. WHAT test	1	0.1667
Synergy vs. Eichhoff	0.2329	0.0026
Synergy vs. Finkelstein	<0.0001 (p <0.05)	0.0002 (p <0.05)

WHAT = wrist hyperflexion and abduction of the thumb.

Table 4. Calculation of the positive predictive value of the active maneuvers.

Test	TP	FP	PPV
Synergy	37	0	100%
WHAT	37	1	97.37%

TP = true positive; FP = false positive; PPV = positive predictive value; WHAT = wrist hyperflexion and abduction of the thumb.

DISCUSSION

Classically, de Quervain's disease is diagnosed by passive maneuvers, such as the Eichhoff and Finkelstein tests.[1-3] The function of these two maneuvers is to provoke passive mobilization of the tendons of the first extensor compartment causing or accentuating the pain referred by the patient.

The WHAT test is a new maneuver that actively evaluates the first extensor compartment of the wrist. It was described in 2014.[3] According to the authors, this test has the advantage of enabling the patient to stop at any time, allowing them to control the intensity of pain during the maneuver.

Taking into account Ruland and Hogan's study on the extensor carpi ulnaris synergy test[5] and the study conducted by Shah et al.[6] on the importance of the abductor pollicis longus in wrist mobility, we decided to describe a new active maneuver to increase sensitivity and specificity in the diagnosis of the disease.

The results obtained show that active maneuvers are superior to passive maneuvers for a correct diagnosis; in this case, the proposed synergy test is the most specific.

This test has the advantage of being a very reproducible maneuver and allows the patient to decide when to stop the test in relation to the pain.

A weakness of the study is the small sample size and short time frame, as it was conducted over a few months. Its strengths include a prospective design, a disease-specific approach, the use of multiple diagnostic maneuvers and imaging studies to confirm and rule out the disease.

This maneuver should not replace those already described in the literature, but should be used as a complement to the physical tests used for the diagnosis of the disease. This could have the benefit of reducing the need for expensive imaging studies.

Moreover, using both maneuvers together could increase the positive predictive value. It should be noted that both maneuvers have a high positive predictive value.

We hope to develop a study with a much more representative sample to support these observations.

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High-Strength Suture Fixation in Metacarpal Fractures

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ABSTRACT
Introduction: Metacarpal fractures are highly prevalent in traumatology. When a surgeon determines that surgical treatment is required, numerous techniques are available, including K-wire fixation, open reduction and internal fixation with plates and screws, interfragmentary screws, and intramedullary screws, among others. **Materials and Methods:** This study included 19 patients with long oblique or spiral shaft fractures of the second to fifth metacarpals, who were treated with open reduction and high-strength suture internal fixation. The average follow-up period was 20 months. Radiographs and functional scales were used to document clinical outcomes. **Results:** Fracture consolidation was achieved in all patients, and they were able to resume their previous activities after an average of 2.3 months. One patient lost the initial reduction due to a failure to comply with medical instructions but achieved fracture consolidation without the need for additional procedures. **Conclusion:** The technique described herein provided a strong metal-free fixation with good clinical outcomes at a low cost.
Keywords: Metacarpal fractures; high-strength sutures; Nice knot.
Level of Evidence: IV

Fijación con sutura de alta resistencia para fracturas de metacarpianos

RESUMEN
Introducción: Las fracturas de metacarpianos son comunes en la práctica traumatológica. El cirujano dispone de diferentes opciones cuando decide implementar un tratamiento quirúrgico, como fijación percutánea con agujas de Kirschner, reducción abierta y fijación interna con placas y tornillos, tornillos interfragmentarios y tornillos endomedulares, entre otras. **Materiales y Métodos:** Se trató a 19 pacientes con fracturas diafisarias oblicuas largas o espiroideas del 2.º al 5.º metacarpiano mediante la reducción abierta y fijación interna con suturas de alta resistencia. El tiempo promedio de seguimiento fue de 20 meses. Se utilizaron radiografías y escalas funcionales para documentar los resultados obtenidos. **Resultados:** La fractura consolidó en todos los pacientes quienes retornaron a sus actividades en un promedio de 2.3 meses. Un paciente perdió la reducción inicial por no respetar las indicaciones médicas, pero la fractura consolidó sin necesidad de una nueva intervención. **Conclusión:** El método propuesto proporcionó una reducción anatómica, una fijación estable libre de metal y buenos resultados funcionales.
Palabras clave: Fractura; metacarpianos; suturas; nudo Nice.
Nivel de Evidencia: IV

INTRODUCTION

Diaphyseal fractures of the metacarpals are common in orthopedic practice. They are usually associated with angulation, rotation or shortening deformities. For those requiring surgical treatment, surgeons now have various alternatives, including percutaneous stabilization with K-wires, open reduction and internal fixation with plates and screws, interfragmentary or intramedullary screws, among others.[1,2]

Multiple studies have been published on the different methods of osteosynthesis for this type of fracture, with varying outcomes. Complications to consider when choosing this treatment include postoperative stiffness, tendon injury, or an additional procedure to remove the osteosynthesis material. Given the advantages and disadvantages of each method, as well as the range of outcomes reported with each method, there is currently no global consensus on how to treat these fractures.[3]

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High-strength sutures have been used for years in all types of trauma and orthopedic procedures. They are often used as an aid in the reduction of third fragments in long bones. Complex procedures have recently been successfully conducted using only high-strength sutures, such as those described by Dr. Hachem in 'metal-free' arthroscopic Latarjet surgery, resulting in adequate fixation of the bone block until consolidation.[4]

On the other hand, the Nice knot described by Pascal Boileau made with high-strength sutures has been a useful and versatile contribution. Its sliding design allows working from a distance and in reduced spaces, and its strength and resistance are remarkable.[5] It is simple and easy to reproduce. It is currently used in a variety of arthroscopic and open procedures; nevertheless, its effectiveness in bone fragment reduction and fixation, as well as whether its usage can interfere with bone healing, remains uncertain.

The aim of this article is to present a technique for the treatment of long oblique or spiral fractures of the 2nd to 5th metacarpals without metal, using only high-strength sutures in combination with a Nice knot, and the outcomes obtained.

MATERIALS AND METHODS

Between February 2019 and November 2021, 20 patients with diaphyseal fractures of the second, third, fourth, and fifth metacarpals with long oblique or long spiral single lines and no other associated injuries underwent surgery with high-strength sutures. One patient was withdrawn from the study because he failed to attend the controls after returning to work, making it impossible to conduct the appropriate follow-up. Those with short oblique or transverse fractures, associated tendon or ligament injuries and follow-up <18 months were excluded.

Patients underwent surgery under regional anesthesia (brachial plexus block) and with a hemostatic tourniquet. A longitudinal dorsal approach was performed over the fracture site and progressed through planes, carefully separating extensor tendons and neurovascular elements. The dorsal periosteum of the metacarpal was opened longitudinally. The fracture was then looped with a double high-strength suture (USP 2 braided non-absorbable polyethylene) and a curved forceps under and outside both fragments (Figure 1) or through the fracture site (Figure 2) being careful not to bring volar structures into the loop, before tying the Nice knot and a simple locking knot (Figures 3 and 4). After the fracture was reduced, a second loop was made. The knot should lie to one side to avoid friction with the extensor tendon and it is preferred to avoid excessive loop tension.

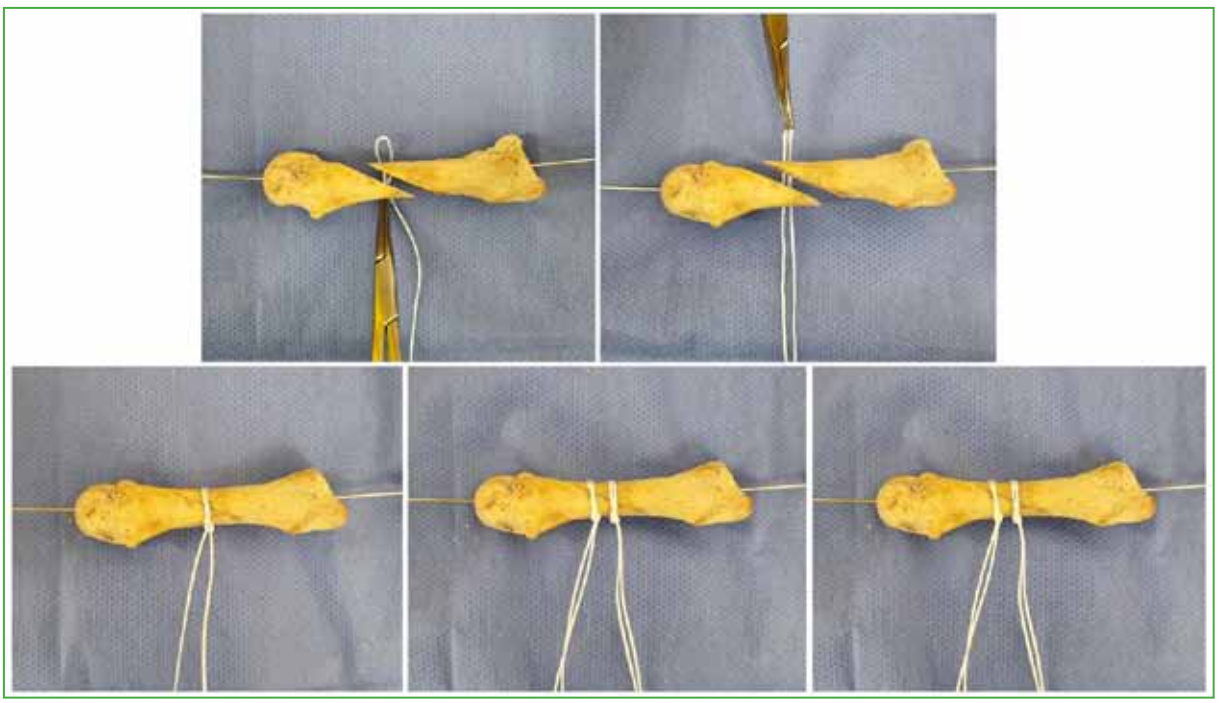

Figure 1. Fracture loop outside the fracture site.

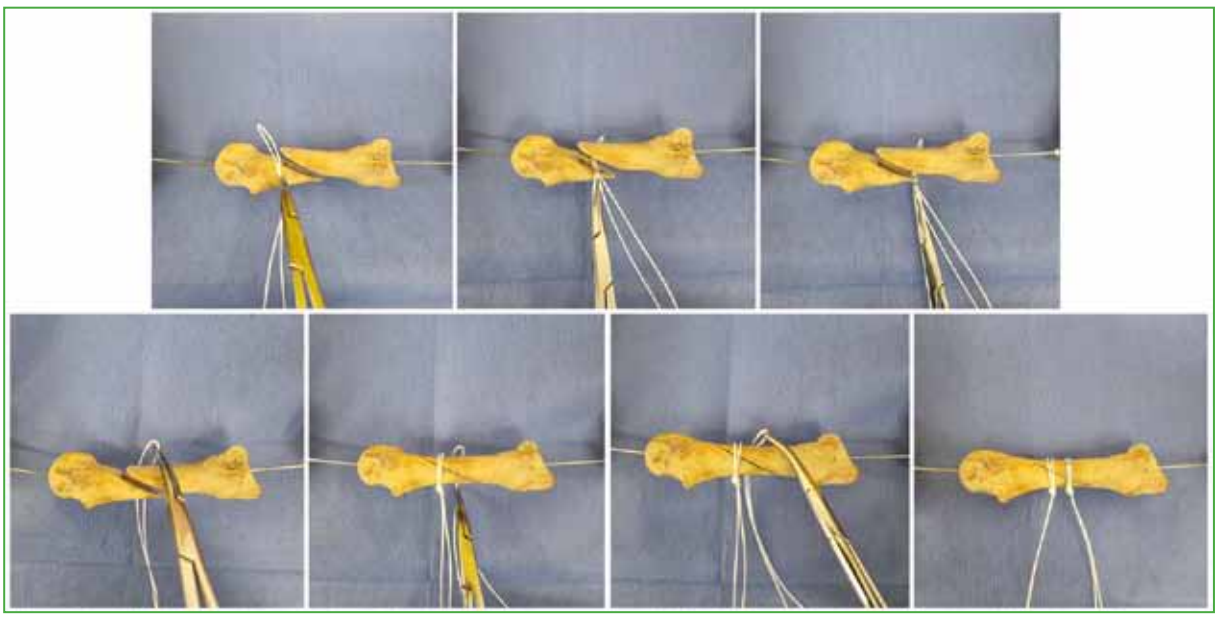

Figure 2. Fracture loop through the fracture focus.

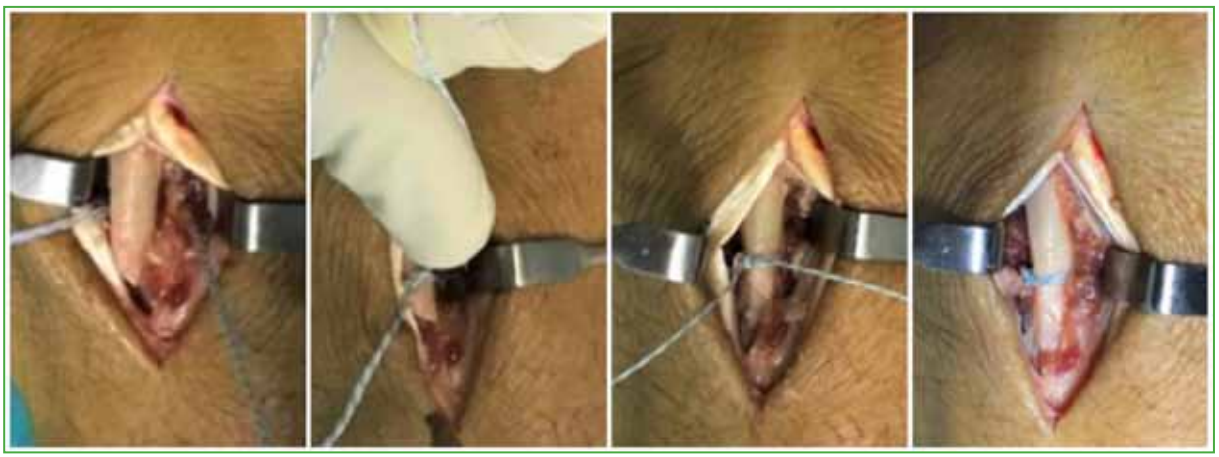

Figure 3. Reduction and fixation with suture and Nice knot (first loop).

Fluoroscopy was used to verify fracture reduction and stability while mobilizing the fingers and wrist. Finally, the periosteum was sutured around the high-strength thread, and the skin was closed. A volar long arm plaster splint was placed with the wrist in slight 20-30º extension.

Patients were instructed to perform gentle flexion-extension movements with their fingers on the first postoperative day. Controls were performed weekly during the first month after surgery and then as needed. Two weeks after the operation, the immobilization was removed and rehabilitation with physical therapy began. Control radiographs were taken at weeks 4, 6 and 8 (Figure 5). Radiographic control was also performed 12 and 18 months after the intervention. The minimum follow-up time was 18 months (mean 20 months). At discharge, they were assessed with the QuickDASH score and the *Total Active Motion Rating Scale* (TAM).

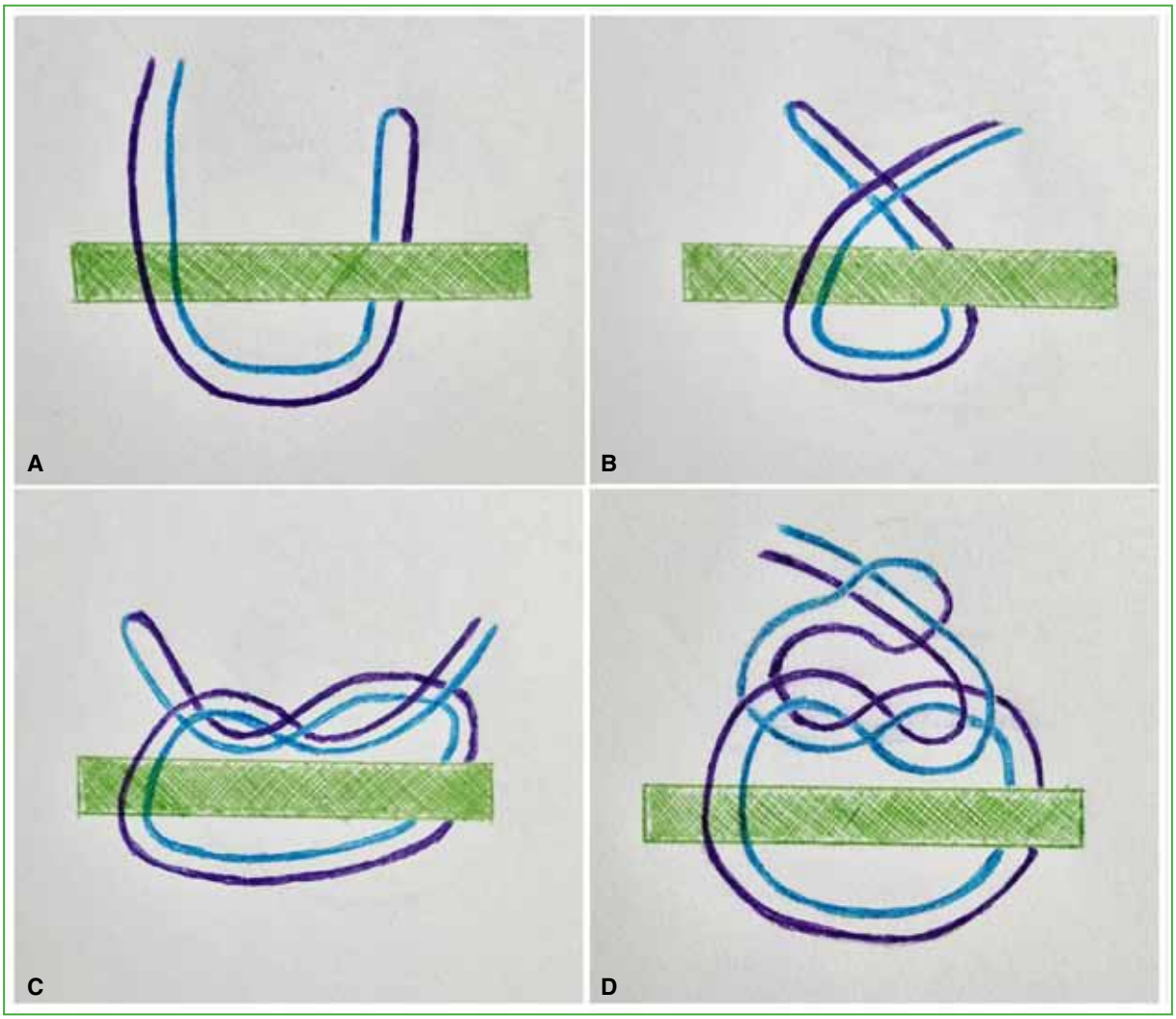

Figure 4. **A.** Fracture loop in double configuration. **B and C.** Simple knot. **D.** The two free ends are threaded into the loop formed by the opposite end of the suture.

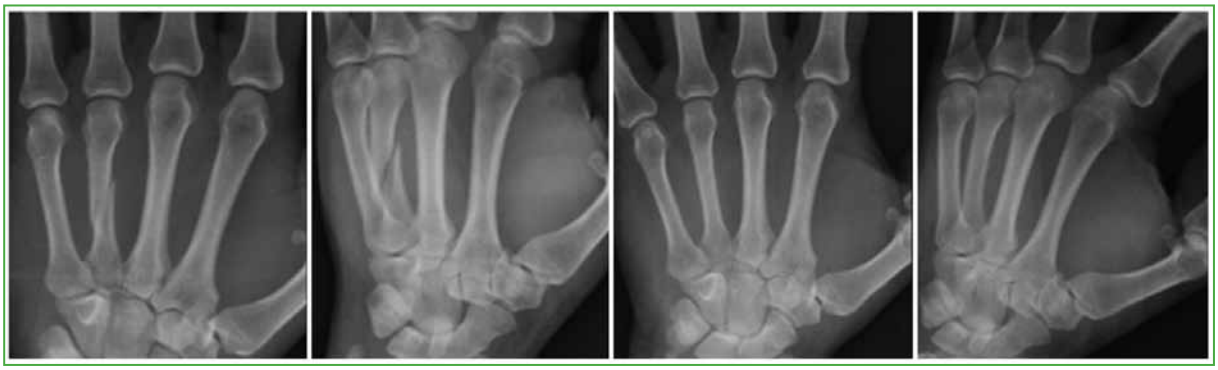

Figure 5. Preoperative and postoperative hand radiographs, AP and oblique. Note the reduction without metal implant.

RESULTS

The study population consisted of 17 men and two women (age range 18-53 years; mean 28). The fractures were caused by acute trauma, and most occurred on the dominant hand (11 cases) and on the 4th metacarpal (8 cases). Surgeries were performed, on average, nine days after the trauma.

Clinical and radiological bone consolidation was observed between week 5 and 7 in all patients. The average time to discharge and return to normal activities and work was 2.3 months.

The functional outcome obtained, according to QuickDASH and TAM scores, was good (according to the *American Society for Surgery of the Hand* classification) and no second intervention was necessary. The average functional range determined by the TAM score was 245° (range 230°-260°). The mean QuickDASH score at discharge was 13.51 (range 4.54-29.54) (Table).

Table. Outcomes.

Patient	Age (years)	Sex	Bone	Side	Dominance	Surgical delay (days)	Time to discharge (months)	Follow-up (months)	QuickDASH at discharge	TAM at discharge
1	25	M	4.º	R	R	4	2	22	11.36	250
2	43	M	4.º	R	R	9	3	18	20.45	250
3	26	M	5.º	L	R	3	1.75	20	15.90	230
4	28	M	3.º	R	R	11	2.5	18	18.18	240
5	24	M	4.º	L	R	8	1.75	18	22.72	260
6	53	M	5.º	R	R	5	3	24	29.54	240
7	18	M	3.º	R	L	15	2.5	18	6.81	250
8	32	M	4.º	L	R	13	2	24	13.63	230
9	27	F	2.º	R	R	7	2.25	18	11.36	230
10	19	M	5.º	R	R	9	2.5	21	4.54	240
11	21	F	2.º	L	R	10	1.75	24	4.54	260
12	30	M	4.º	R	L	7	2	18	9.09	260
13	27	M	3.º	R	R	6	2.5	18	11.36	230
14	24	M	4.º	L	R	7	3	24	9.09	260
15	31	M	2.º	R	R	9	3	20	13.63	240
16	25	M	5.º	R	R	8	2	29	15.90	240
17	36	M	2.º	L	L	10	2	18	25	230
18	22	M	4.º	R	R	9	2.5	18	6.81	250
19	26	M	4.º	L	R	14	2.25	18	6.81	260

M = male; F = female; R = right; L = left; TAM = Total Active Motion Rating Scale.

One patient (5.26%) initially lost the reduction because he did not follow the medical indications. The displacement was tolerable and he was immobilized with a plaster splint. Consolidation was achieved and did not require further surgery.

During the follow-up time, no other complications were recorded.

DISCUSSION

When faced with metacarpal fractures, the surgeon must choose the appropriate treatment among multiple options. Variables such as location, fracture type and surgeon experience are determining factors in this choice.

Currently, high-strength sutures are used in multiple procedures as a temporary aid in the reduction of small fragments.[6] The tightness achieved with two loops of high-strength sutures in conjunction with the Nice knot was so effective in intraoperative tests and under fluoroscopy that we soon began to notice that adding metallic material to this construct did not confer greater advantages and, on the contrary, exposed us to more complications.

In this study, we have been able to demonstrate that high-strength sutures in the described configuration can reduce this type of fracture while providing sufficiently stable fixation to eliminate the need for additional metal components such as K-wires, plates, or screws. The authors of the study observed that selecting the correct fracture type for this novel treatment was critical to its success. Short, comminuted oblique fractures have an instability that cannot be adequately controlled with this technique. Regarding concerns about the suture interfering with the process of bone callus formation, such complication was not observed in this study.

Other surgical techniques have resulted in a variety of complications, including lack of consolidation, stiffness, extensor tendon irritation, infection, loss of reduction, and osteosynthesis material failure.

In a series of 32 metacarpal fractures treated with intramedullary wires, van Bussel et al. reported excellent outcomes in all cases. However, 81% of the patients had to be operated on again to remove the used material, resulting in higher operating costs and a longer recovery period for the patient.[7]

Dreyfuss et al. compared the outcomes obtained in fractures treated with locking plates or pins, and concluded that plates provided fewer complications and better outcomes.[8]

Similarly, Ozer et al. reported 13% loss of reduction and 15 reoperations for material removal in a series of 38 metacarpal fractures treated with intramedullary nailing.[9] In our study, the rate of loss of reduction was lower (5.26%).

Reduction and internal fixation with plates and screws appear to be related with a more rigid fixation, but also with increased stiffness and irritation of the extensor tendons.

In the study by Fusetti et al., the complication rate was 32% in a group of 81 metacarpal fractures treated with plates and screws, e.g. delayed healing (15%), stiffness (10%), loosening or breakage of the osteosynthesis material (8%).[10]

In 1999, Brüser et al. published a technique for the treatment of metacarpal fractures using transosseous resorbable hemi-cerclage sutures. The study included patients with oblique, spiral and comminuted fractures, both articular and extra-articular. They were discharged in an average of 6.1 weeks and only one had to be operated on again for delayed consolidation during follow-up (7.5 weeks).[11]

During this study and follow-up, a second surgery for material removal or tenolysis was not necessary.

One limitation of this study is the small sample of patients.

CONCLUSIONS

This surgical technique for the resolution of metacarpal fractures with oblique or long spiral lines has been effective, reliable and reproducible. The complication rate was low and postoperative recovery was good.

The technique provided an anatomical reduction, stable fixation and achieved good functional outcomes.

Follow-up with further studies will provide us with more information that will allow us to evaluate this technique as an alternative method for the resolution of these fractures.

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Patient Experience Evaluation and Cost Savings Analysis of Carpal Tunnel Syndrome Decompression Surgery Using the WALANT Technique

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ABSTRACT

Introduction: Wide-awake local anesthesia no tourniquet (WALANT) is an anesthetic technique that was developed to improve patient access to treatment and optimize the use of available medical resources in hand surgery. The main purpose of this study was to evaluate patient experience and hospital cost savings during surgical treatment of carpal tunnel syndrome (CTS) with this technique at a South American public hospital. **Materials and Methods:** Between 2016 and 2022, a descriptive prospective observational study was conducted on patients with a clinical diagnosis of CTS who had undergone surgical treatment. Patient satisfaction was assessed using a questionnaire that asked about pain during different periods of time, anxiety, and the procedure itself. The costs of the anesthetic technique were also analyzed. **Results:** 92 patients were evaluated and the majority of them were satisfied with their WALANT experience; 94.5% said they would choose this procedure again, citing low levels of pain and anxiety. A cost reduction of 60.6% per procedure was achieved. **Conclusions:** CTS decompression with the WALANT technique resulted in significant cost savings for the national health system, as well as favorable outcomes in terms of satisfaction, anxiety, and pain; the procedure was safe, comfortable, and efficient. The benefits and profitability of employing fewer hospital resources could be further optimized and replicated to result in significant health-care cost savings.
Keywords: Hand; carpal tunnel syndrome; local anesthesia; epinephrine.
Level of Evidence: IV

Experiencia del paciente y análisis de ahorro de costos de la cirugía de síndrome de túnel carpiano con técnica WALANT

RESUMEN

Introducción: La técnica de anestesia local con epinefrina sin el uso de manguito hemostático (*Wide Awake Local Anesthesia - No Tourniquet*, WALANT) se desarrolló para mejorar el acceso a la atención de la cirugía de mano y optimizar recursos médicos. El principal objetivo de este estudio fue evaluar la experiencia del paciente y analizar el ahorro de costos hospitalarios en el tratamiento quirúrgico de descompresión del síndrome del túnel carpiano utilizando esta técnica anestésica. **Materiales y Métodos:** Se realizó un estudio descriptivo prospectivo observacional en pacientes con diagnóstico clínico de STC operados entre 2016 y 2022. El grado de satisfacción del paciente fue evaluado mediante un cuestionario sobre el dolor en diferentes momentos, ansiedad y experiencia con el procedimiento. También se analizaron los costos de la técnica anestésica. **Resultados:** Se evaluó a 92 pacientes. La mayoría se mostró satisfecha y el 94,5% confirmó que volvería a elegir este procedimiento, los niveles de dolor y ansiedad fueron bajos. Se registró un ahorro de costos del 60,6% por procedimiento. **Conclusiones:** La descompresión del síndrome del túnel carpiano con técnica WALANT generó un ahorro de costos considerable para el sistema de salud nacional, los resultados fueron buenos sobre la base de la satisfacción, la ansiedad y el dolor; y es un procedimiento seguro, cómodo y eficiente. Los beneficios y su rentabilidad al emplear menos recursos hospitalarios podrían ser optimizados y reproducidos para generar un ahorro considerable en gastos de salud.
Palabras clave: Mano; síndrome del túnel carpiano; anestesia local; epinefrina.
Nivel de Evidencia: IV

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common compressive neuropathy in the upper limb and affects an estimated 3-5% of the population.[1] It is characterized by a set of symptoms consisting of pain, numbness and paresthesia in the sensitive territory of the median nerve caused by compression in its passage through the carpal tunnel.[2] It is usually treated with surgery, and is one of the most frequent interventions in hand surgery.[3] The surgical procedure is based on the decompression of the median nerve by resecting the transverse carpal ligament.[4]

In recent years, the use of local anesthesia with epinephrine without the use of a hemostatic tourniquet for outpatient surgery has become widespread in numerous surgical procedures of the hand and wrist. This technique, known as WALANT (*Wide Awake Local Anesthesia – No Tourniquet*), allows us to evaluate finger function and range of motion during the operation while keeping the patient awake and without the need for sedation or a hemostatic tourniquet, which can cause discomfort.[5] Patients who undergo hand surgery with the WALANT technique are as satisfied as those who have traditional surgery because it prevents nausea and vomiting, reduces urinary retention and dizziness caused by sedation, increases independence because no escort is required after surgery, and is more efficient because it requires fewer preoperative visits.[6]

The WALANT technique has been shown to result in significant savings in the hospital sector by eliminating expenses related to preoperative medical tests, perioperative nursing, anesthesiology, supplies, and medicines,[7,8] but no studies have evaluated this benefit in Argentina.

The main objective of this study was to evaluate the patient experience and cost savings in CTS decompression surgery using the WALANT technique in a national hospital center.

MATERIALS AND METHODS

An observational prospective descriptive study was conducted. The population consisted of 92 patients with a clinical diagnosis of CTS,[2] operated on by the author, together with an assistant, between February 2016 and July 2022. Surgery was indicated after failure of conservative treatment (anti-inflammatory agents, kinesiology plus nocturnal splints). The demographic characteristics recorded were: gender, age, dominant hand, affected hand, and work activity: active or retired (Table 1).

Table 1. Demographic characteristics of the sample (n = 92).

	Male	Female	n = 92
Sex, n (%)	24 (26.1%)	68 (73.9%)	
Age (mean)	69.12 (min. 38, max. 85)	62.14 (min. 20, max. 89)	63.96 (min. 20, max. 89)
Dominant hand			
Right	19	67	86
Left	3	3	6
Affected hand, n (%)			
Right	12 (50%)	41 (61%)	53 (34.3%)
Left	12 (50%)	27 (39%)	39 (57.6%)
Work activity, n (%)			
Active	12 (50%)	38 (56%)	50 (54.4)
Retired	12 (50%)	30 (44%)	42 (45.6)

Patients diagnosed with CTS based on clinical symptoms and verified with electromyography were included.[9] Patients aged <18 years or previously treated with CTS decompression, those with other neuropathy requiring surgery at the same time, Raynaud syndrome, pregnancy, history of severe procedure anxiety, inability to lie supine on a surgical table due to low back pain or obstructive sleep apnea, and history of adverse reactions to local anesthesia were excluded.

The requested preoperative studies were: a chest radiograph and an electrocardiogram (both with reports), and a complete blood count and coagulation test. No anesthetic evaluation was requested. The patient's usual medication, including anticoagulants, was not discontinued.[10] As per the institution's protocol, the patients fasted for 8 hours before the procedure.

Procedural protocol for hand surgery with the WALANT technique

The injection technique and dosage for the procedure were based on the descriptions of Lalonde and Wong:[5] 2% lidocaine with 20 mg/ml bottle epinephrine (formula available in Argentina: each 100 ml contains 2% lidocaine hydrochloride 2 g). All procedures were performed with aseptic technique without cardiopulmonary monitoring or venoclysis. Unlike the original technique described by Lalonde, sodium bicarbonate was not used as a buffer due to unavailability in the hospital.

When the patient is admitted to the operation room, they are positioned supine with their wrist supinating on a hand table.

The anesthetic technique begins with a 15/5 intradermal needle infiltrating the skin 1 cm proximal to the proximal wrist crease on the axis of the third commissure while avoiding superficial veins. 1 cc is infiltrated and the surgeon waits 30 seconds. The needle is replaced with a 50/8 intramuscular needle, which is inserted into the same hole and infiltrates the remaining anesthetic solution from the 20 ml syringe proximally, distally, medially, and laterally.

20 minutes are set aside to begin with the placement of the surgical fields, this adds between 5 and 10 min that favor the vasoconstrictive effect of epinephrine.[11]

Surgical technique

A 3 cm incision is made distal to the distal wrist crease on the axis of the third commissure. The distal edge of the transverse carpal ligament is identified. The entire ligament, including the distal antebrachial fascia, is sectioned along the ulnar edge of the palmaris longus tendon (Figure 1). The skin is washed with physiological solution and closed.

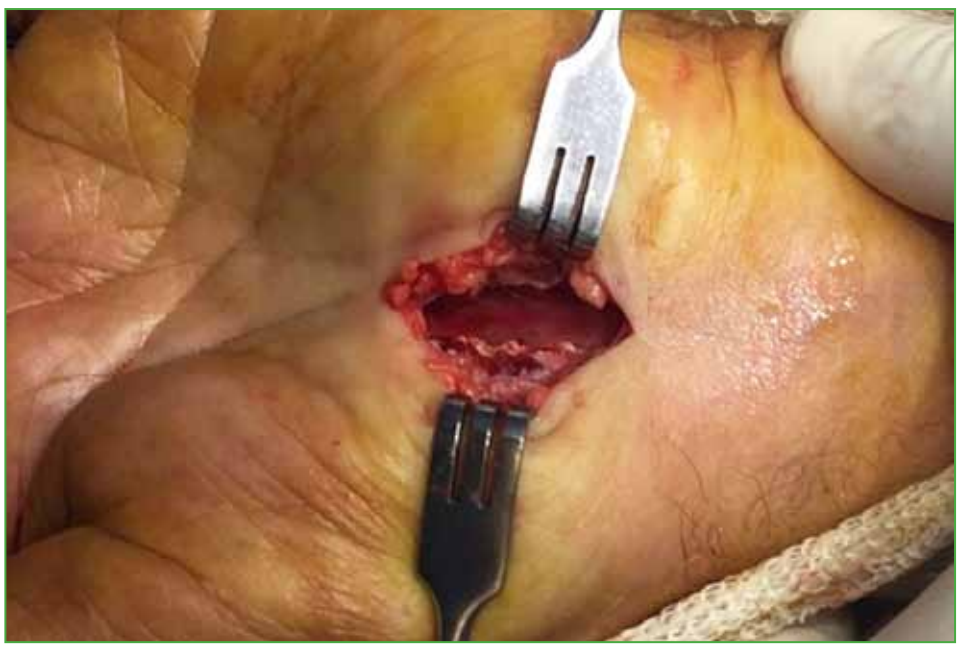

Figure 1. 69-year-old woman. Decompression of carpal tunnel syndrome in the left hand.

After the procedure, patients are given postoperative care instructions and information on signs of concern before being discharged without staying in the anesthesia recovery room. Nonsteroidal anti-inflammatory agents are prescribed for pain relief. In a 24-hour control, the dressings are changed, while the sutures are removed two weeks later.

Complications and adverse events related to the procedure

Postoperative complications that were characterized as general or directly attributed to the WALANT procedure were recorded, such as finger necrosis, infection, hematoma, neuropraxia. Additionally, any adverse events that occurred during the WALANT procedure that were unrelated to the underlying disease, such as vasovagal syncope or atypical pain, were recorded as well.

Patient experience

The patients' perspectives on their anesthetic experiences were documented in a questionnaire completed during the first postoperative consultation, 24 hours after the procedure. Patient acceptance of the WALANT procedure, pre- and post-operative pain and anxiety were assessed using the modified Davison questionnaire.[6] Pain and anxiety were determined with the visual analogue scale (VAS), where 0 indicates no pain or anxiety and 10, worst pain or worst anxiety (Table 1).

Cost Savings Analysis

Costs were based on the hospital's fee schedule: surgical procedure, code CP-121710 Median nerve decompression at the carpal tunnel level; procedure anesthesia, code HC-161004 Adult major anesthesia (the code does not distinguish general anesthesia or regional block) and anesthesia evaluation, code HC-165081 Anesthesia evaluation. These costs include direct costs, defined as those that directly affect actual surgery, such as used drugs, and disposable supplies; and indirect costs that are those linked to the procedure, and are included in the value of the surgery for the establishment, including transcription fees, sterilization costs, and salaries of medical and cleaning assistants. Values are expressed in dollars due to changes in the exchange rate of the local currency*.

Statistical methods

Student's t test for two-tailed unpaired data and Mann-Whitney U test for continuous variables were used to compare variables between groups. The repeated measures ANOVA test was used to compare means of three or more groups where participants are the same in each group. A p-value <0.05 was considered statistically significant.

RESULTS

92 patients were evaluated over seven years. The series consisted of 24 women and 68 men, with an average age of 63.96 years (min: 20, max. 89), with predominant age ranges between the sixth and seventh decades of life. In 86 patients, the dominant hand was the right, and in six, the left. However, the percentage of affected hands was similar, with a slight predominance of the left hand (57.6%) over the right hand (34.3%). 54.4% of patients were occupationally active and 45.6% were retired (Table 2). The results of the electromyography were: eight mild cases (8.7%), 60 moderate cases (65.2%) and 24 severe cases (26.1%).

There were no general or procedural complications. None had critical digital ischemia, nor was it necessary to discontinue the procedure due to pain or anxiety, nor to indicate hospitalization after the intervention. Three (3.26%) required prolonged observation (more than 15 min) for dizziness in the immediate postoperative period. Patients treated with anticoagulant agents did not have any postoperative complications.

Everyone completed the follow-up. Regarding the modified Davison questionnaire on patient experience, 94.5% (87 patients) stated that they would undergo the procedure again under WALANT anesthesia if it had to be operated on again. The rest reported that they would prefer sedation (5.4%).

*1 US dollar = 24.10 Argentine pesos. May 2018 - Based on the daily U.S. currency quote published by Banco Nación (www.bna.com.ar).

Table 2. Questionnaire: Patient experience

1. Pain during the procedure (VAS 0-10).
   a) needle insertion.
   b) infiltration of anesthetic fluid.
   c) during surgery.
2. How severe was your pain after surgery? (VAS 0-10)
3. Did you need to take medication for the first 12 hours after your surgery? Yes No
4. Did your medicine manage the pain? Yes No
5. Were you able to sleep well the first night after your surgery? (VAS 0-10)
6. How anxious (nervous) were you about your surgery? (VAS 0-10)
7. How anxious (nervous) did you feel after your surgery? (VAS 0-10)
8. If you had to have the same surgery again and were given a choice, would you rather be awake or sedated for surgery?

VAS = visual analog scale.

Pain intensity assessed by VAS was 4.38 ± 2.20 during needle insertion (Table 3) and 3.13 ± 1.77 at the time of fluid injection.

Table 3. Pain assessment.

	Mean	Standard deviation	Minimum	Maximum	95% confidence interval
Needle insertion	4.38	2.20	1	9	3.93- 4.84
Liquid injection	3.13	1.77	1	71	2.76- 3.50
Intraoperative pain	1.59	0.71	1	5	1.44- 1.73
Postoperative pain	2.77	1.84	0	8	2.39- 3.15

The score for pain during surgery was 1.59 ± 0.71. Pain measurement after surgery was 2.77 ± 1.84 ($p < 0.00001$) (Figure 2). 64.1% of patients (n = 59) needed analgesics after surgery and, in 97.8% of cases (n = 90), pain subsided with prescribed medication, except in two patients in whom it subsided after 24 hours. The VAS score for rest during the first night was favorable (2.45 ± 1.46).

Average values of anxiety were: 3.97 ± 1.79 before the procedure and 1.35 ± 0.89 ($p < 0.05$) after (Figure 3).

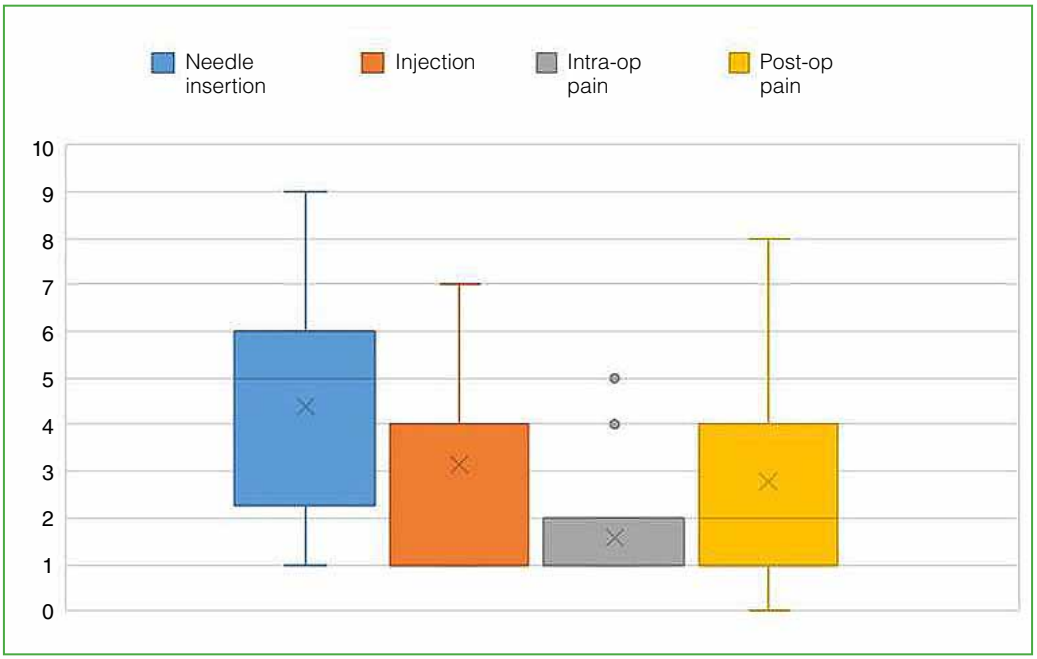

Figure 2. Pain assessment plot at different times of the procedure.

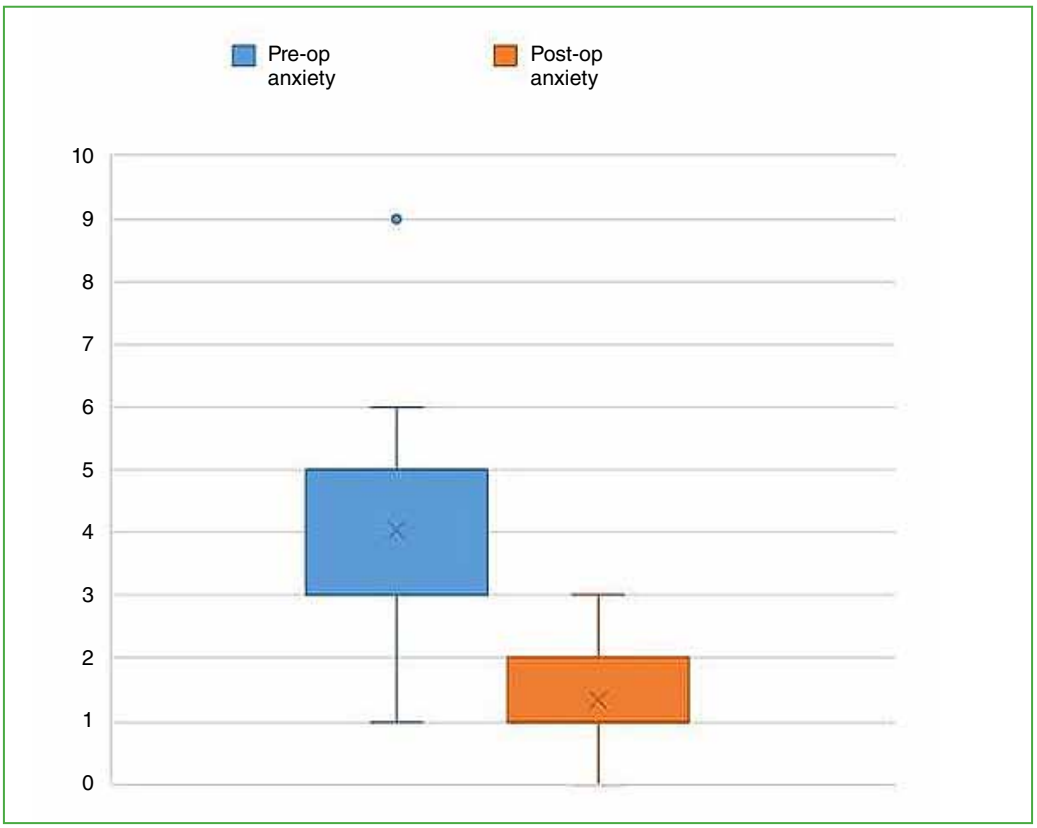

Figure 3. Anxiety assessment plot before and after the procedure.

The institutional cost of the CTS decompression procedure was compared with that of the use of general anesthesia or regional anesthetic block (Table 4).

Table 4. Cost-effectiveness of carpal tunnel syndrome decompression using the WALANT technique or general anesthesia or block.

	Cost of WALANT technique	Cost of anesthesia procedure	Comparative cost savings
Anesthetic evaluation	-	25.1	-25.1 (100%)
Procedure	98.34	224.39	-126.05 (56.2%)
(n = 1)	98.34	249.49	-151.15 (60.6%)
Carpal tunnel syndrome n = 92	9047.30	22953.84	-13906.54 (60.6%)

The total savings were 60.6%, taking into account the sum of the cost of the anesthetic evaluation and the procedure itself for one case and for the total of 92 cases analyzed (Figure 4).

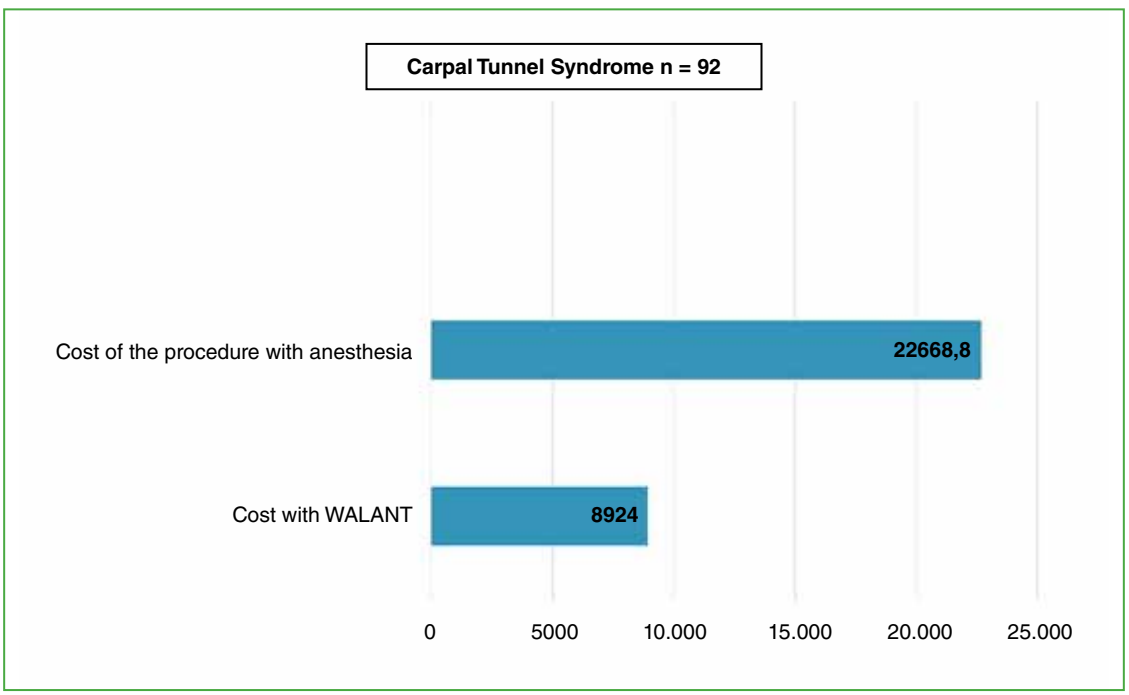

Figure 4. Cost graph for the WALANT technique compared to general anesthesia or block (n = 92).

The total cost savings for the institution during the evaluated period of the WALANT procedure versus the same procedure if performed under anesthesia were US$ 13,906.54 in total (Table 4). Table 5 provides a detailed comparison of the disposable supplies required for a regional block vs anesthesia with the WALANT technique, indicating that the latter uses fewer resources (Figure 5).

Table 5. Comparison of disposable supplies and commonly used drugs in a regional block vs. the WALANT technique.

		Anesthesia	WALANT
Disposable supplies	15/5 Intradermal needle	1	1
	50/8 Intramuscular needle	1	1
	22G 500 mm Anesthesia needle	1	
	Guedel cannula	1	
	Nasal cannula	1	
	Intravenous catheter	1	
	Gauze (package)	1	1
	Pair of gloves	1	1
	Macrodrip tubing	1	
	20 mL Syringe	2	1
	10 mL Syringe	3	
	5 mL Syringe	1	
	3-way key	1	
	Mandrel	1	
	Laryngeal mask	1	
	Extension line	1	
	Endotracheal tube	1	
Drugs	1 5 ml Atrobutin ampoule	1	
	1 10 ml Ethylephrine/Ephedrine ampoule	1	
	20 ml Lidocaine 2% with epinephrine	1	1
	20 ml Lidocaine 2% without epinephrine	1	
	1 5 ml Midazolam ampoule	1	
	10 ml Ropivacaine 7.5 mg/ml	1	
	500 cc Saline	1	

DISCUSSION

In recent years, interest in hand and wrist surgeries using the WALANT technique has increased because it has been shown to be safe and cost-effective.[12] The use of epinephrine anesthetic agents has long been discouraged because of the presumed risk of acute ischemia in the fingers, although their safety has been demonstrated in several articles, such as Lalonde et al., in 2005, with a series of more than 3000 patients,[13] or the literature review by Thomson et al.[14] on cases attributed to digital epinephrine necrosis. Before 1948, , when this myth originated, the only local anesthetic accessible was procaine; at the time, expiration dates did not exist, therefore, its acid pH level could reach even 1, making it extremely unsafe; that is, the cause of the necrosis was procaine, but epinephrine was blamed.[15] It should be highlighted that, while four cases of digital necrosis have recently been reported after injecting lidocaine with epinephrine,[16] all of them were caused by infiltrating directly into the flexor sheath, which was discouraged in the original technique.[5] In this study, no patient developed critical ischemia.

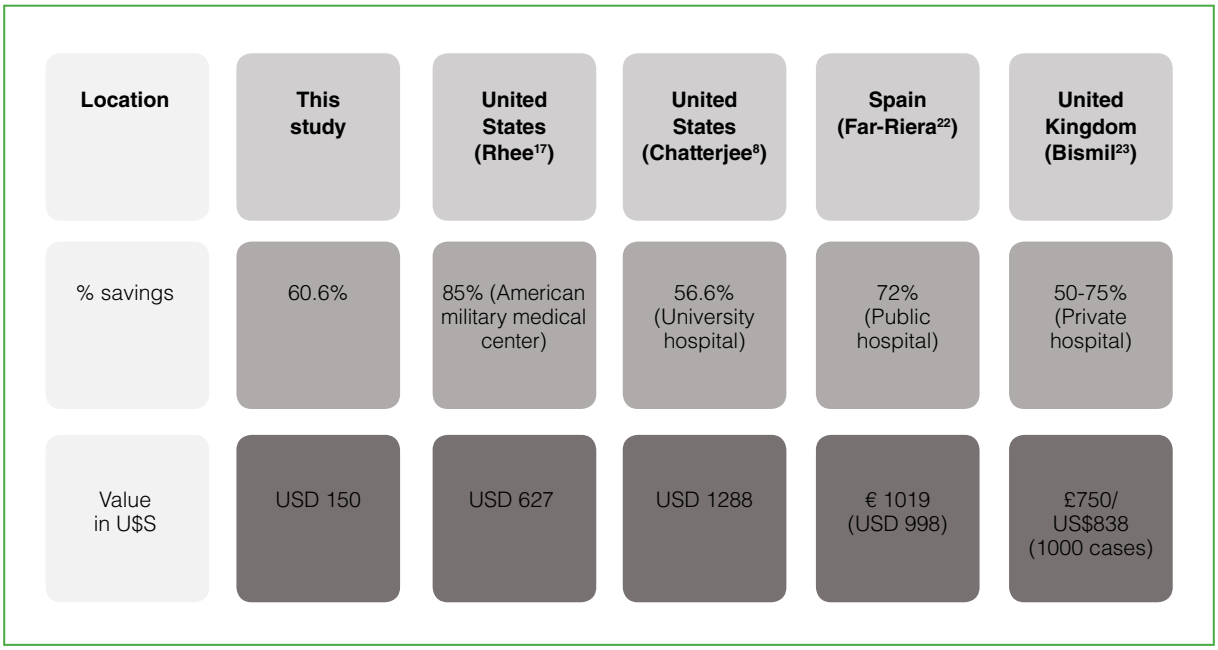

Figure 5. Disposable supplies and drugs used for WALANT vs. disposable supplies, laryngoscope and drugs used for regional block.

In terms of patient experience, the procedure's acceptance rate was high (94.5%), similar to that obtained by Rhee et al.,[17] who, in evaluating the preference over intravenous anesthetist-assisted sedation, found that patients would prefer the WALANT technique if they had surgery again, due to the shorter time involved thanks to the elimination of standardized preoperative medical consultations, not having to change medication or dietary routines, and the absence of the postoperative nausea commonly associated with sedation. Furthermore, Gallucci et al.[18] found that when they compared this anesthetic technique with a control group that used a hemostatic tourniquet, the outcomes were similar in terms of patient satisfaction.

Different elements have been described as possible causes of preoperative pain: introduction of the hypodermic needle through the skin, increased tension of tissues in the palm as a result of volume infiltration, and pain associated with the temperature or acidity of the anesthetic.[19] However, pain during and after surgery has been reported to be equivalent to that of sedation procedures. Davison et al.[6] reported that 64% of patients rated perioperative pain as less than a routine dental procedure, and stressed that pain attributed to the WALANT procedure may be influenced by local anesthetic injection technique and nerve block quality. Another factor that can influence pain assessment, as described by Braithwaite et al.,[20] is intraoperative pain, which can become up to twice as severe with the use of the hemostatic tourniquet compared to only local infiltration plus epinephrine. Because it normally causes discomfort after a certain time, not using the tourniquet favors lower pain scores and improves the patient's intraoperative well-being.

Patients and surgeons may have reservations about WALANT procedures because of the possibility of considerable perioperative anxiety, as patients are fully awake without sedation. In the study group, the scores on this item in the VAS were relatively low, this could even correspond to the fact that they had already been given enough information about the characteristics of the procedure. These values are similar to those of the study by Davison et al.[6] who reported significantly lower preoperative anxiety for the WALANT technique (2.3 ± 2.7) than for sedation (3.4 ± 2.8; p = 0.007). Satisfaction levels in his group also reached 93%.

Teo et al.[21] reported that 86% of patients who underwent the WALANT technique for different hand surgical procedures would choose the same anesthetic technique again, as well as to be able to remain awake during surgery. 91% of respondents felt that the pain suffered during surgery was comparable to that of a dental procedure and that anxiety levels were generally low.

The general data gathered in this study demonstrate that the costs of the WALANT technique allow for an average saving of 60.6% when compared to the institution's value for general anesthesia or regional anesthetic block. Figure 5 shows a cost comparison of other authors in various countries.

The main limitation of this study is not comparing the study group with a control group including patients who underwent anesthetist-assisted sedation or wore hemostatic tourniquets. Although this was one of the initial objectives, the study's extension over time resulted in many of the institution's hand surgeons gradually transitioning to less invasive and more efficient anesthesia, leading to almost no use of sedation for this procedure in the last three years. Furthermore, the discontinuation of surgeries due to the health emergency* during the COVID-19 pandemic in 2020 and part of 2021 resulted in a much lower number of both groups in comparison to the control group, leading to an important statistical bias between the groups. Therefore, estimates of this type are qualitative and based on studies published under conventional anesthesia.

Another limitation was the inability to account for a breakdown of the cost of medical supplies used and the cost of post-operative analgesia, which would have yielded more precise results. However, the savings evidenced by the WALANT technique represent a positive impact on the health system economy and patient satisfaction.

CONCLUSIONS

CTS decompression with the WALANT technique results in considerable cost savings for the national health system, is well tolerated by the vast majority of patients, and good outcomes are achieved in terms of satisfaction, perioperative anxiety, and pain. The benefits and cost-effectiveness of using fewer hospital resources with a safe, comfortable and efficient technique could be optimized and replicated in the healthcare units of the national health system to generate extremely significant savings in health costs.

Conflict of interest: The author declares no conflicts of interest.

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3D Printing for Surgical Planning and Resolution in Orthopaedic Surgery. Case Series

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ABSTRACT

Introduction: The popularity of 3D printing-assisted surgery has surged over the previous decade. The tool's limited use in our context prevents us from taking advantage of all of its applications and benefits for the patient. **Materials and Methods:** A retrospective study on lower limb disease in patients treated at our institution, analyzing each stage of the procedure and its applicability in planning, surgical execution, and implant development. **Results:** We describe 12 cases in which 3D printing was used to treat acetabular defects, bone tumor resections, and long bone sequelae. **Conclusions:** Our series and the literature reviewed demonstrate that 3D printing-assisted surgery improves plan predictability while also reducing surgical times, bleeding, and intraoperative radiation at a reasonable cost. Furthermore, no complications from this technology have been reported.

Keywords: 3D printing; additive manufacturing; anatomical models; custom implants.
Level of Evidence: IV

Impresión 3D aplicada a la planificación y la resolución quirúrgicas en la cirugía ortopédica. Serie de casos

RESUMEN

Introducción: La popularidad de la cirugía asistida con impresión 3D ha crecido en los últimos 10 años. El poco empleo en nuestro medio no permite aprovechar para el paciente todas las aplicaciones y los beneficios de esta herramienta. **Materiales y Métodos:** Estudio retrospectivo sobre enfermedad del miembro inferior en pacientes tratados en nuestra institución analizando cada etapa del proceso y su utilidad en la planificación, la ejecución quirúrgica y el desarrollo de implantes. **Resultados:** Se describen 12 casos en los que se utilizó la impresión 3D para tratar defectos acetabulares, resecciones tumorales óseas y secuelas en huesos largos. **Conclusiones:** Nuestra serie y la bibliografía revisada demuestran que la cirugía asistida con impresión 3D mejora la predictibilidad con lo planificado y reduce los tiempos quirúrgicos, el sangrado y la radiación intraoperatoria, a un costo accesible. Además, no se han comunicado complicaciones asociadas a esta tecnología.

Palabras clave: Impresión 3D; fabricación aditiva; modelos anatómicos; implantes a medida.
Nivel de Evidencia: IV

INTRODUCTION

3D printing, also known as additive manufacturing, was a pioneering technique when it was introduced, in the 1980s, for industrial and engineering purposes.[1] 3D printing technology is increasingly applied in the health sector, due to its decreasing cost and increased accessibility. Since 2014, there has been a rise in publications indicating a growing interest in this topic.[2] Currently, 3D printing of the bone segments to be treated is a tool that helps the understanding, planning, and execution of the surgical procedure, particularly in complex or atypical cases.[3] The prints are designed using DICOM (*Digital Imaging and Communications in Medicine*) tomography or magnetic resonance images, which are then segmented and printed according to the region to be treated. From a cost-benefit

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perspective, 3D printing-assisted surgery is an appealing option for institutions that cannot afford computer-assisted surgery.[4] These digital models can also be used to create patient-specific instruments such as cutting guides, final external fixators, and implant placement guides, as first described by Radermacher et al. in 1999.[5]

Because it is not yet standard practice in the orthopedic field, both surgeons and bioengineers have limited experience and require continual feedback between the surgeon's needs and the alternatives that the bioengineer can provide.

Our aim is to describe a series of cases in which 3D printing was used for the surgical planning and resolution of patients with an orthopedic condition, analyzing qualitatively the stages of use, benefits, and complications.

MATERIALS AND METHODS

We conducted a retrospective analysis of patients treated in the Lower Limb Sector of our institution's Orthopaedics and Traumatology Service from its beginning to March 2022. The inclusion criteria defined were: lower limb condition (from pelvis to foot) and use of 3D printing at any stage of the therapeutic process. Exclusion criteria were: follow-up <2 years in patients undergoing arthroplasty.

The following information was gathered from each case: the design and development process, the stage of use of 3D printing (planning, execution, or prosthetic design), the type of design for execution, and whether there were any complications associated with the printing.

The work process for designing the prints was as follows (Figures 1 and 2):

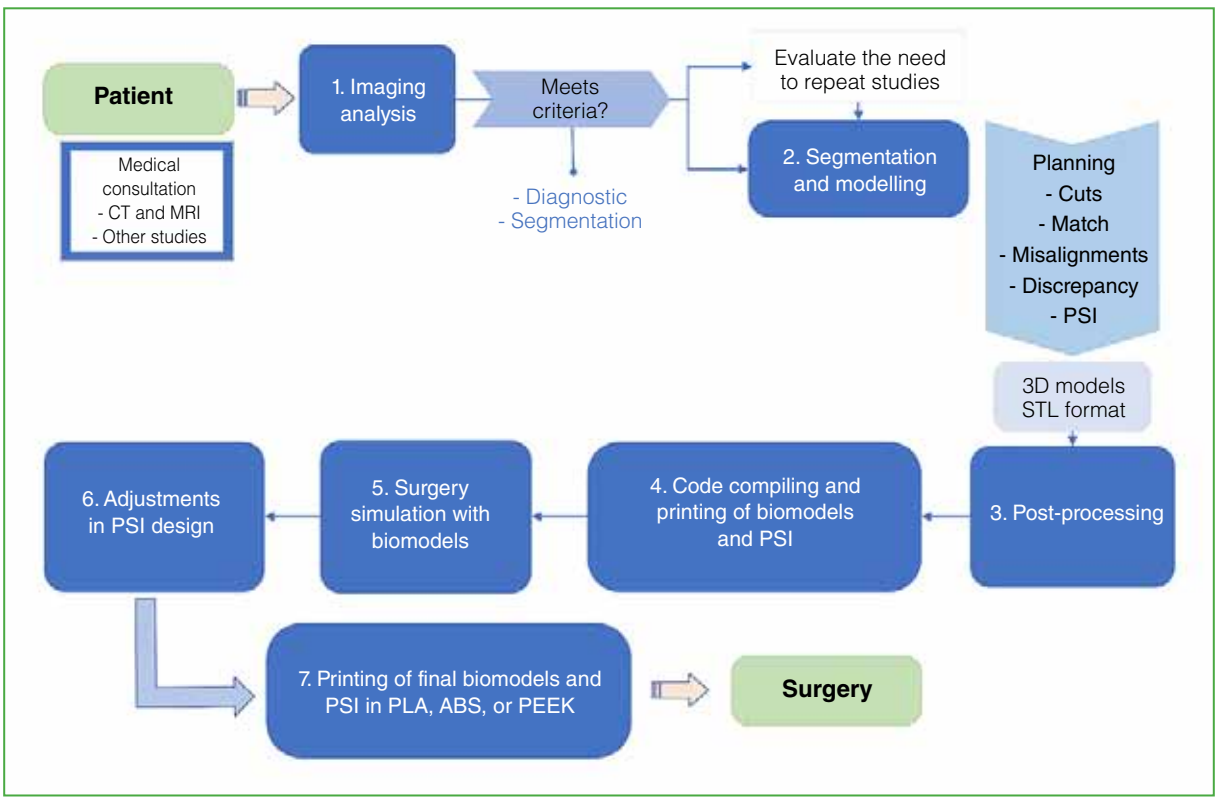

Figure 1. Standard work process for using 3D technology.

1. Image analysis in RadiAnt.
   a) CT scans (contrast-enhanced), 1 mm thick and 512 x 512 square matrix.
   b) MRI, without specific image acquisition parameters.
2. Segmentation and modeling in 3D Slicer.
3. Post-processing in MeshMixer and Blender.
4. Code compiling in Simplify for additive printing of a test 3D model with or without guide or implant design in AutoDesk Fusion.
5. Surgical simulation and evaluation of results in the models.
6. Design of guides and implants in AutoDesk Fusion according to tests.
7. Surgical procedure in the patient.

Steps 4, 5 and 6 can be repeated until the design meets the specifications of the case to be resolved. During the process, in-person or virtual meetings were held with the bioengineering team. When cases were more complex, a daily written record of progress and obstacles was also implemented in GoogleDocs.

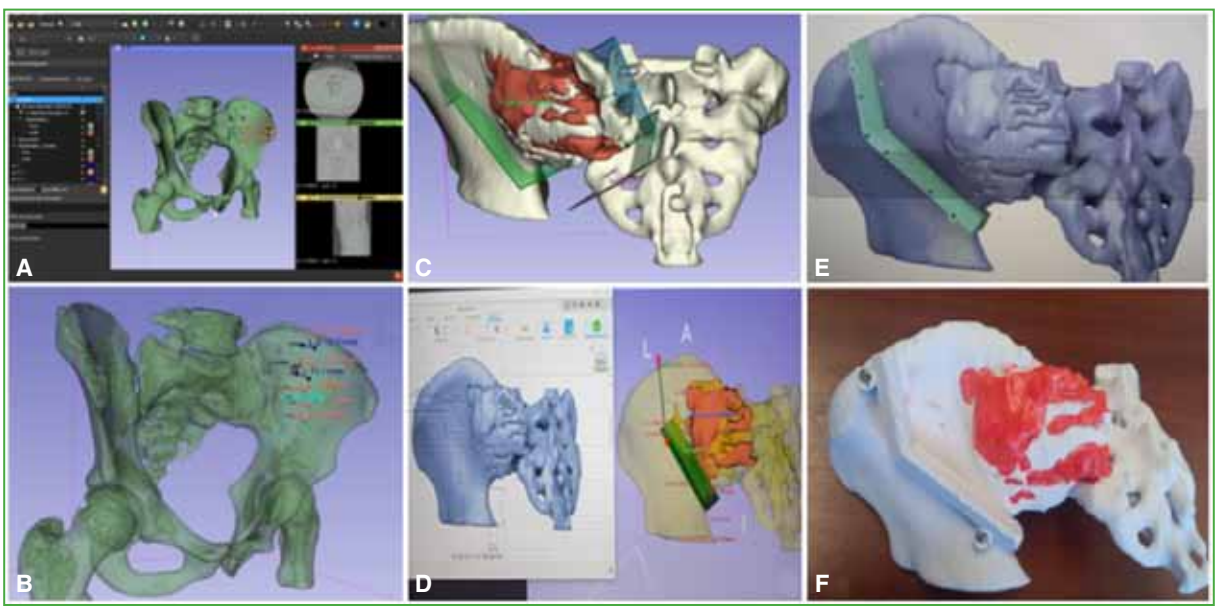

Figure 2. Workflow for cutting guides for a grade 2 chondrosarcoma in Enneking's zone IV of the pelvis. **A.** Segmentation, analysis and marking of the surgical margin. **B.** Determination of the plane of iliac osteotomy. **C.** 3D model (tumor in red) with iliac and sacral osteotomy planes. **D.** Cutting guide design according to planning. **E.** Final guide design and congruence test. **F.** Biomodel and printed guide ready for testing.

RESULTS

Our series included 12 cases where 3D printing was used for diagnosis, planning and treatment. In eight patients, the process was performed entirely in our hospital, while the remaining four required the assistance of another institution for titanium implant printing. With regard to patient-specific instruments, cutting guides were designed in five cases as well as a custom mold for the spacer with antibiotic cement. Three custom acetabular implants were created, two of which required additional screw placement guides (Figure 3).

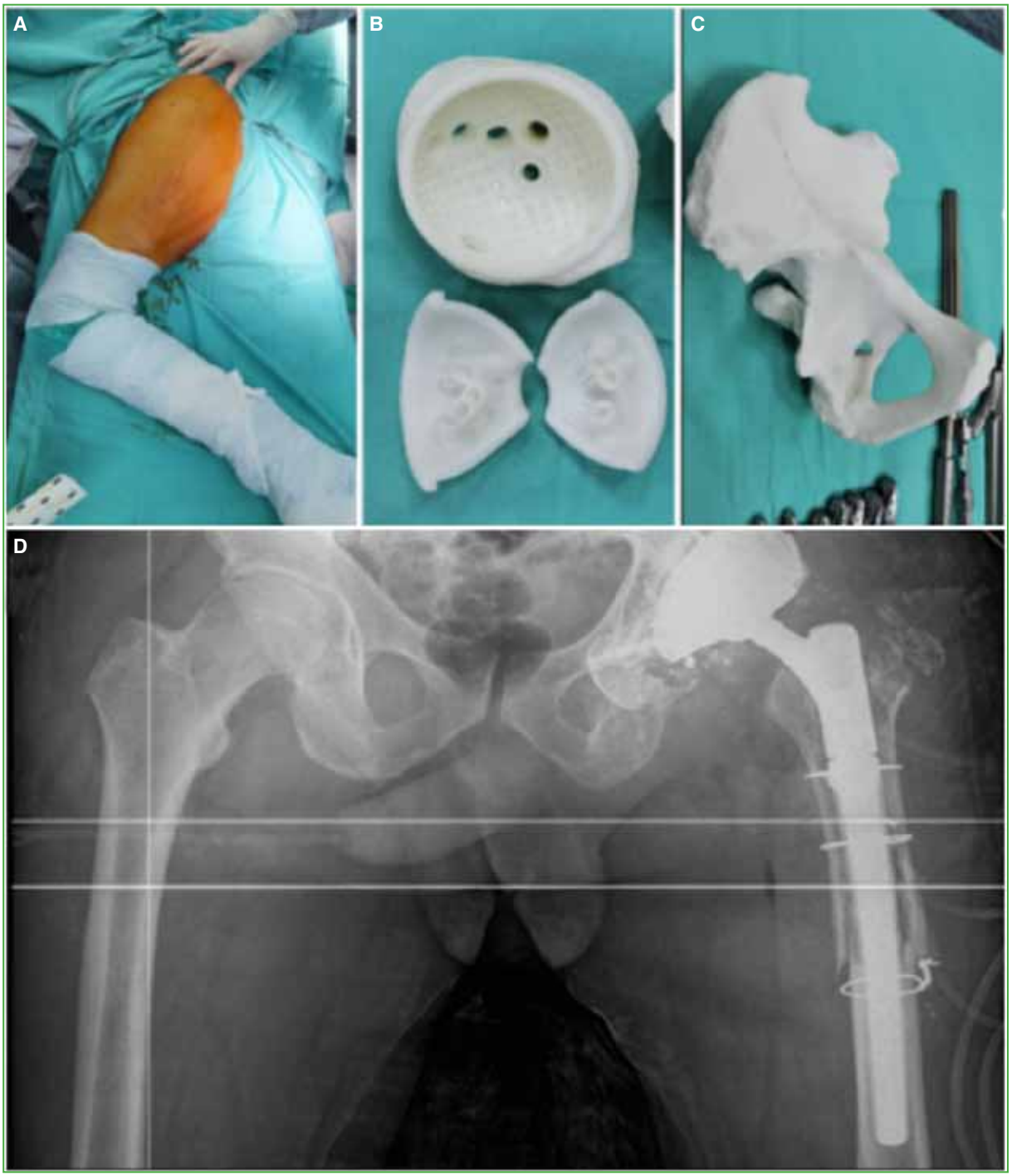

Figure 3. Case 1. 53-year-old woman with severe acetabular defect. Development of custom implants and screw guide. **A-C.** Intraoperative images. **D.** Anteroposterior radiograph of both hips. Postoperative outcome.

As for the patients, five were women and seven were men. The average age was 39 years. In young patients (average 26 years), tumor disease or sequelae were more common, while in older patients (average 60 years), complications of arthroplasty were most common.

The treated conditions were: correction of posttraumatic deformities, clubfoot sequelae, bone oncology resections and reconstruction of complex acetabular defects (Table).

Table. Description of the clinical picture and the application of 3D printing for its treatment.

Patient	Sex	Age	Disease	Planning	Execution *(PSI)*	Customized implant	Process
1	F	53	Acetabular defect	Yes	Screw guide	Yes	External
2	M	82	Acetabular defect	Yes	Screw guide	Yes	External
3	F	63	Tibial malunion	Yes	External fixator		Institutional
4	M	25	Tibial nonunion	Yes	Cutting guide		Institutional
5	M	17	Clubfoot sequelae	Yes			Institutional
6	F	12	Chondrosarcoma of the sacrum/pelvis	Yes	Cutting guide		Institutional
7	M	24	Osteosarcoma of the sacrum/pelvis	Yes			Institutional
8	M	21	GCT of the distal femur	Yes	Cutting guide		Institutional
9	F	26	Post-traumatic femoral sequelae	Yes	Cutting guide	Yes	External
10	M	59	Infected periprosthetic fracture	Yes	Spacer mold		Institutional
11	M	47	Acetabular defect	Yes		Yes	External
12	M	21	GCT of the distal femur	Yes	Cutting guide		Institutional

M = male; F = female; GCT = giant cell tumor.

All cases included digital planning, with the programs available mainly for measuring and determining oncology margins, osteotomy angles, quantifying the required graft volume, and bone stock available for implant insertion. Surgical procedures were developed as planned, with the printed biomodels. No additional intra-surgical procedures were needed. In patients with tumor and allograft disease, the initial surgical plan was modified according to the availability of biomodels; these modifications consisted mainly of the location of the resection planes (Figure 4). In allograft reconstruction, two simultaneous surgical teams were formed, one for oncology resection and the other for bank graft processing; a similar situation occurred with the custom cement spacer, where one team was in charge of debridement and another formed the spacer.

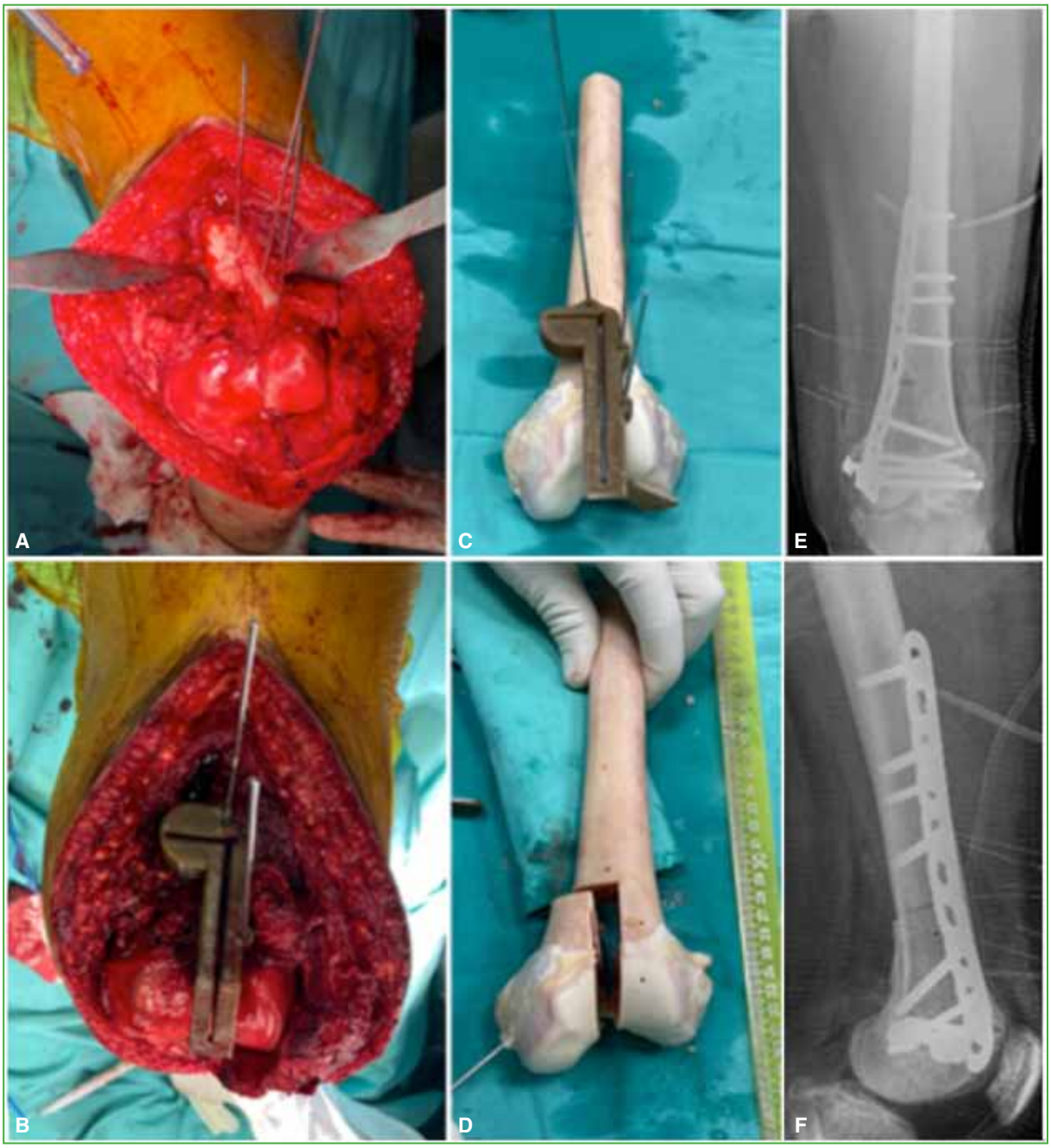

Figure 4. Case 8. 21-year-old male. Tumor resection and reconstruction with structural bone graft. **A and B.** Tumor resection with 3D guidance. **C and D.** Structural bone section with guide for proper congruence with the patient's bone. **E and F.** Radiographs of the left knee. Post-surgical control.

A similar situation occurred with the pre-assembly of the circular external fixator (Figure 5), which was designed on a printed biomodel and then sterilized after assembly. At the time of the intervention, it was only necessary to position the Schanz screws in the planned sites according to 3D planning and attach them to the rings.

Fluoroscopy was used only to examine the osteotomy plans and the positioning of implants and grafts at the end of the procedure.

Figure 5. Case 3. 63-year-old woman. Malunion. The segment to be treated is printed to ensure appropriate and precise assembly before surgery.

It took an average of five meetings between medical and bioengineering professionals per patient. When specific implants or devices were designed, there were more meetings than when digital planning was used alone.

No custom implant presented loosening at two years of follow-up.

In the series of cases described, there were no post-surgical complications associated with the use of this tool, both in implant placement and cutting guides.

DISCUSSION

3D printing is a tool that provides information for professional education and training, as well as planning and treatment in complex or atypical surgical scenarios. In a review of 227 articles, it was shown that the application of this technology decreases surgical time, improves outcomes and reduces radiation exposure.[6] This was also the case in our series, as the formation of two simultaneous teams allowed to reduce the processing times of grafting or forming spacers. The use of cutting guides resulted in the decrease of the total fluoroscopy time, as it was not necessary to determine the level of the osteotomies or perform new measurements during surgery.

The circular external fixator was already created, which reduced the amount of time required for intraoperative assembly.

In a 2019 publication, the change in assessment and planning of distal tibia fractures by new and experienced surgeons was examined. After using 3D printing for planning, 74% and 9%, respectively, changed their plan and approach.[7] In our series, the biomodels allowed us to anticipate difficulties and improve the accuracy of the surgical plan, such as in the case of triplanar deformities, where various circular fixator configurations were tested until a suitable design was achieved and compatible with the proposed osteotomies, or bone bank allograft cases, where the cutting planes were modified to maximize anatomical compatibility between donor and recipient.

An experimental study with 10 cadaveric specimens was conducted to evaluate the design of cutting guides for tumor resection in the pelvis, and a non-statistically significant mean error was found when compared to computer-assisted procedures.[8] Furthermore, it decreases the learning curve and experience required to obtain comparable outcomes among young surgeons and trained professionals.[7] In our patients, the guidelines enabled accurate reproducibility between what was planned and what was executed in the operating room. Another application for cutting guides was to achieve adequate congruence in peek reconstructions in patients undergoing oncology resections, in accordance with the principles of surgical techniques, in order to maximize the possibilities of integration.[8,9]

The material used in the printings for planning was PLA (polylactic acid), a plastic from raw materials, such as starch, tapioca or sugar cane. This plastic is ecological and renewable, and at a certain temperature and humidity, it can be biodegradable, a quality that makes it safe for the environment. The material chosen for the cutting guides was PEEK (polyetheretherketone), a polymer used for the design and manufacture of prostheses and implants with adequate mechanical strength and biocompatibility, since we have a printer suitable for this material.[10,11]

The application of 3D technology offers qualitative and tactile perception benefits that other methods do not; at this point, comparison with other cutting-edge technologies such as computer navigation, augmented reality and robotics is difficult. To date, we have not found studies comparing the results of all these techniques with each other.

We believe the small sample size and heterogeneous composition to be weaknesses of this study. For custom implants, long-term follow-up is only two years (1 case with 5-year follow-up).

When analyzing the disadvantages or complications in 3D printing-assisted surgeries, we have not found complications associated with the use of this tool; therefore, we consider it a safe tool for the procedure. As a disadvantage, because we are still in the learning stage, planning and design required many hours of work and feedback from bioengineers to get the desired outcomes.

It is important to emphasize that it is the first program of assisted surgery with 3D printing with surgeons and bioengineers of the same public institution in the country.

CONCLUSIONS

3D printing, as a complementary tool to surgical procedure planning and execution, improves reproducibility between what is planned and what is executed, resulting in shorter surgery times, less radiation exposure, and the ability to detect potential complications in advance. We must also emphasize that it is a tool that does not represent high costs, unlike computer-assisted surgery, and that no complications have been documented as a result of its use.

Conflict of interest: The authors declare no conflicts of interest.

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Use of 3D Printing Models in Orthopedics and Traumatology: Case Series

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ABSTRACT

Introduction: Understanding and treating deformities, defects and complex fractures remains a challenge in the area of orthopedics and traumatology. 3D printing models are used for diagnostics, surgical planning, the manufacturing of intraoperative guides and implants, and surgical training. The objective of our work was to report on a series of cases where 3D printing was implemented in our service and to carry out a narrative review. The case series includes two acetabular fractures, two idiopathic scoliosis, a complex tibial pilon fracture, and a talar fracture. 3D printing models were used for surgery planning, which benefited both the patient and the surgical team. **Conclusions:** With the rise of 3D printing in orthopedics and traumatology, we are able to better understand fractures and complex deformities, as well as improve preoperative planning. The model's production timelines may be delayed, limiting its usefulness in an emergency. There are yet insufficient studies that report substantial benefits to the patient and medical team, such as reduced surgical time, intraoperative blood loss, and radiation exposure.

Keywords: 3D printing; surgical planning; deformities.

Level of Evidence: IV

Uso de modelos de impresión 3D en Ortopedia y Traumatología: Serie de casos

RESUMEN

Introducción: Comprender y tratar deformidades, defectos y fracturas complejas sigue siendo un desafío en el área de la Ortopedia y Traumatología. La aplicación de modelos de impresión 3D incluye el diagnóstico, la planificación quirúrgica, la creación de guías intraoperatorias e implantes y el entrenamiento quirúrgico. Las deformidades y fracturas articulares complejas representan un reto en el tratamiento quirúrgico debido a la complejidad tridimensional. La tecnología de impresión 3D permite simular la anatomía, la reducción de trazos fracturarios, osteotomías, y la dirección y longitud de tornillos. El objetivo de este artículo es comunicar una serie de casos en los que se implementó la impresión 3D y presentar una revisión narrativa. Se describen dos casos de fractura de acetábulo, dos de escoliosis idiopática, una fractura del pilón tibial compleja y una fractura de astrágalo en los que se crearon modelos de impresión 3D para la planificación quirúrgica que resultaron beneficiosos tanto para el paciente como para el equipo quirúrgico. **Conclusiones:** Con el auge de la impresión 3D en el área de la Ortopedia y Traumatología, podremos facilitar el entendimiento de fracturas y deformidades complejas y mejorar las planificaciones prequirúrgicas. El tiempo de producción del modelo puede demorarse y ser una limitación para su uso en urgencias. Aún faltan estudios para evaluar los beneficios significativos para el paciente y el equipo médico, como la reducción del tiempo operatorio, la pérdida de sangre intraoperatoria y la exposición a la radiación.

Palabras clave: Impresión 3D; planificación quirúrgica; deformidades.

Nivel de Evidencia: IV

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INTRODUCTION

Understanding and treating complex deformities, defects and fractures, particularly joint fractures, continues to be a challenge in the field of Orthopedics and Traumatology. It has been demonstrated that 3D models improve anatomical visualization and surgical planning. However, it is unclear how to best apply the technique and whether it results in superior intraoperative and postoperative outcomes.[1]

This article aims to present a series of cases in which 3D printing was implemented in our Department and a narrative review of its use in the area of Orthopedics and Traumatology.

History and characteristics of 3D printing

The origin of 3D printing dates back to 1859, when François Willème developed the first 3D scanning technology in France, which he called "photo sculpture". Using photographs taken at 360° and with the help of a pantograph, the outlines of the model were drawn to the desired scale, then profiles were cut out and added together to form the three-dimensional sculpture. In 1892 in the United States, Joseph Blanther patented a technology that produced 3D topographic maps using a layering method similar to today's printers.[2] Finally, in 1984, Charles Hall filed the first patent for a 3D printer entitled "Apparatus for production of 3D objects by stereolithography", which was the world's first 3D printer.[3] The first reported use in Orthopedics was in 1999 as a preoperative planning aid for complex spinal surgery.[4]

To use the 3D printer, a high-resolution CT scan of the deformity, fracture or defect is required. The computer-aided design program creates a digitized representation of an object that is then converted into a stereolithography (STL) file. STL files "cut out" the digitized model created by the design program, which allows the 3D printer to print the object layer by layer. The most commonly used 3D printing materials are titanium, acrylonitrile butadiene styrene, and polylactic acid.

Three types of printing methods have been described:

1. Stereolithography: the first method to be created. Ultraviolet light is applied to a cuvette containing resin. The light is controlled by a computer and polymerizes the surface of the resin in the cuvette giving shape to the object. Using a descending piston, more resin is exposed to the light and successive layers are created.

2. Selective laser sintering: it produces objects by pressing powders or other materials that have been previously heated without melting. Ultraviolet light is used as well, however, this time it acts on a powder instead of a liquid resin. Solidifying the material results in a layered addition.

3. Fused deposition modeling: in this case, the material used is a plastic filament that passes through a resistor in a nozzle that heats it to over 200 °C and melts it to deposit it on a moving platform. This technology is simpler and more accessible.

Orthopedics and Traumatology Applications

The application of 3D printing in the medical field includes diagnostics, surgical planning, creation of intraoperative guides and implants, and surgical training.

Regions of the body with complex anatomy, such as the pelvis or spine, are better understood with 3D printing and its use can significantly improve learning.[5] It is useful, for example, for planning osteotomies in cases of severe spinal deformities, as well as for determining the trajectory of pedicle screws.[6] In complex fractures, surgeons can use the fractured 3D model to simulate the reduction technique and use the uninjured 3D model to optimize plate selection.[7]

Case reports indicate that surgical planning can reduce surgery duration, leading to less blood loss and radiation exposure, ultimately improving patient and surgical team safety.

In addition, 3D models were found to improve the patient's understanding of the fracture and communication with the physician, resulting in better compliance with postoperative rehabilitation.[8]

The following is a description of a series of cases from our Service in which 3D printing technology was implemented.

CLINICAL CASE 1

A 20-year-old male was admitted to the Emergency Department after suffering a motorcycle accident. He had a fracture of the left acetabulum in both columns, with a simple line in the posterior column and an iliac line in the anterior (AO classification 6.2-C1.2) (Figure 1A).

Reduction and osteosynthesis was performed with two 3.5-mm reconstruction plates, a 6.5-mm cannulated screw and a one-third tubular plate. The 3D-printed model was designed for surgical planning, and surgery was performed four days after the fracture (Figures 1B and C).

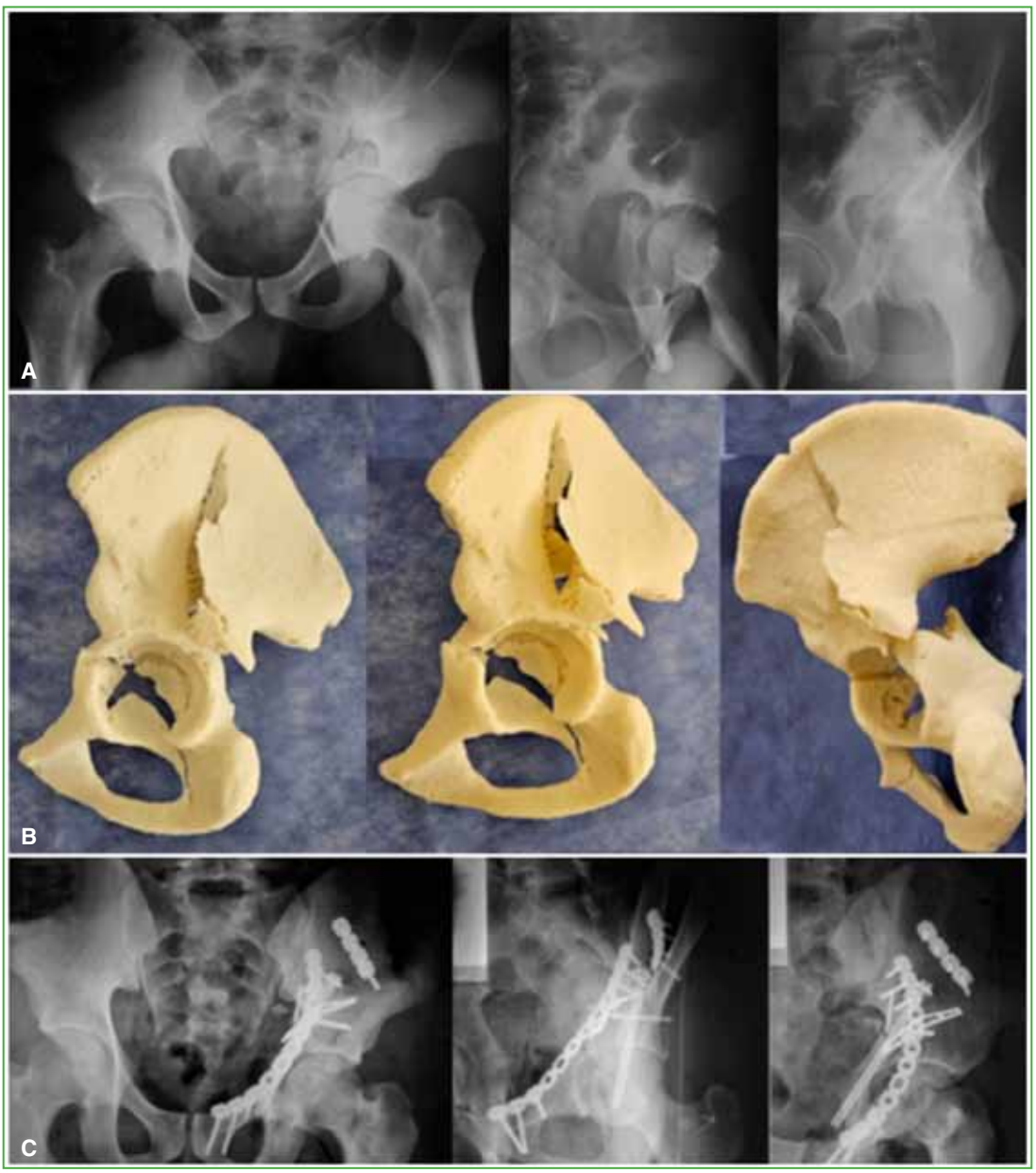

Figure 1. Clinical case 1. **A.** Radiograph. Fracture of the right acetabulum with involvement of both columns. **B.** 3D printed model. **C.** Control radiographic study in the immediate postoperative period.

The replica of the fractured acetabulum provided an accurate representation of the volume, size and orientation of the bone fragments of the compromised columns, and it was used to measure the length of the plates and their respective screws. The surgical team reported that surgical time was optimized and that there were no complications in the placement of the implants.

CLINICAL CASE 2

A 16-year-old male was admitted to the Emergency Department after a motorcycle accident. He had a juxtatectal transverse fracture of the right acetabulum with a high T-shaped line in the anterior column (AO classification 6.2-B.2) (Figure 2A). Reduction and osteosynthesis was performed with a 3.5-mm reconstruction plate and a 6.5-mm cannulated screw, and the 3D printing model was designed for surgical planning. Surgery was performed nine days after the fracture (Figures 2B and C).

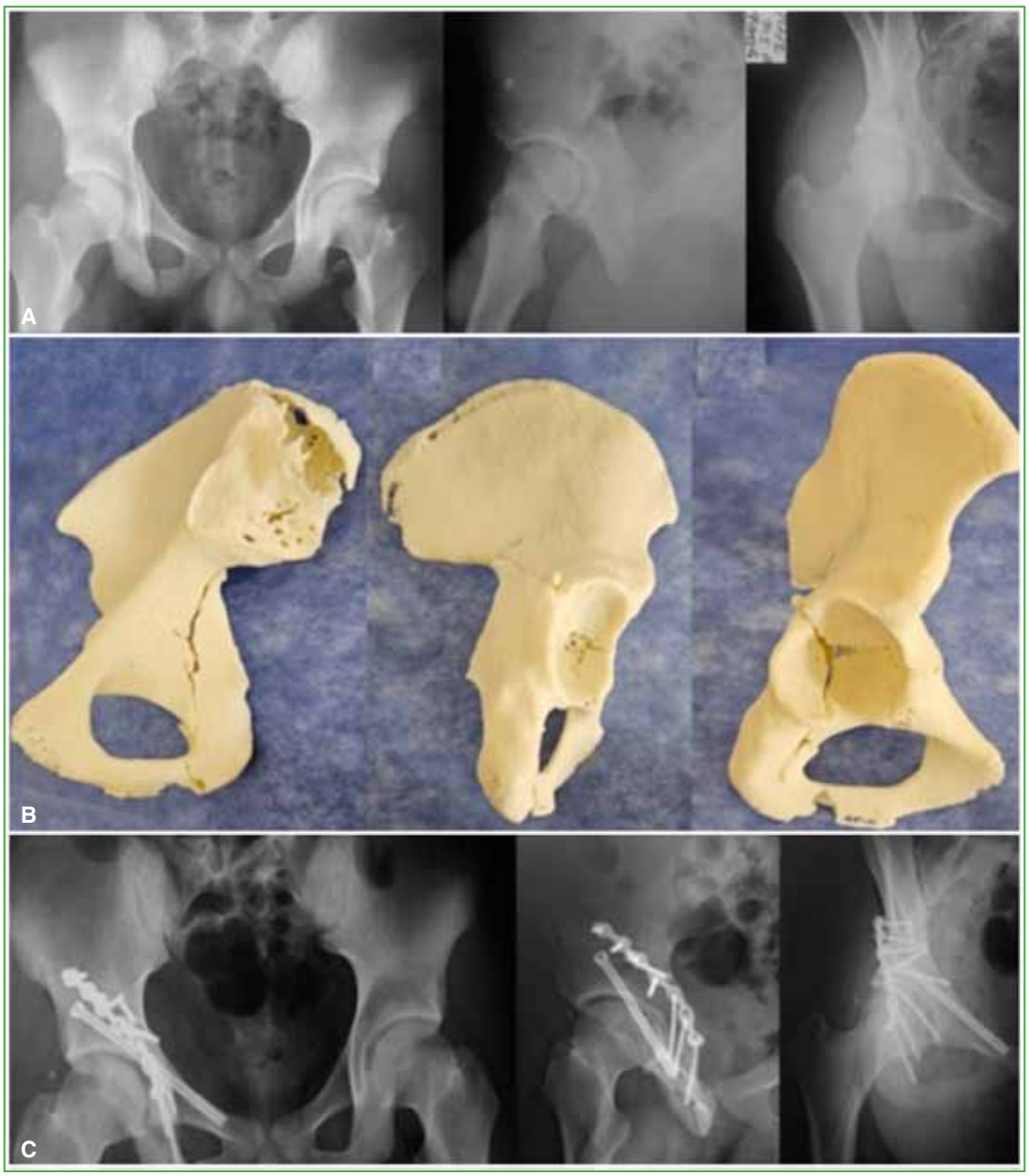

Figure 2. Clinical case 2. **A.** Radiographic study. The T-shaped fracture line in the right acetabulum can be seen. **B.** 3D printed model. **C.** Control radiographic study in the immediate postoperative period.

Surgical planning with the 3D model allowed accurate assessment of the fracture anatomy and planning of the reduction. During the operation, it assisted the surgical team in following the fracture anatomy and placing the implants correctly.

CLINICAL CASE 3

A 39-year-old woman was admitted to the Emergency Department after a fall from height (2 meters). She had a right tibial plafond fracture with a complete intra-articular, complex metaphyseal-complex epiphyseal line (AO classification 4.3-C3) (Figures 3A and B).

In the Emergency Department, reduction and fixation with an external fixator were performed, and reduction and osteosynthesis with two anatomical plates for the distal end of the tibia were proposed as the definitive treatment. Due to the evolution of the soft tissues, this surgery was performed two weeks after the fracture, with previous planning in a 3D model (Figures 3C and D).

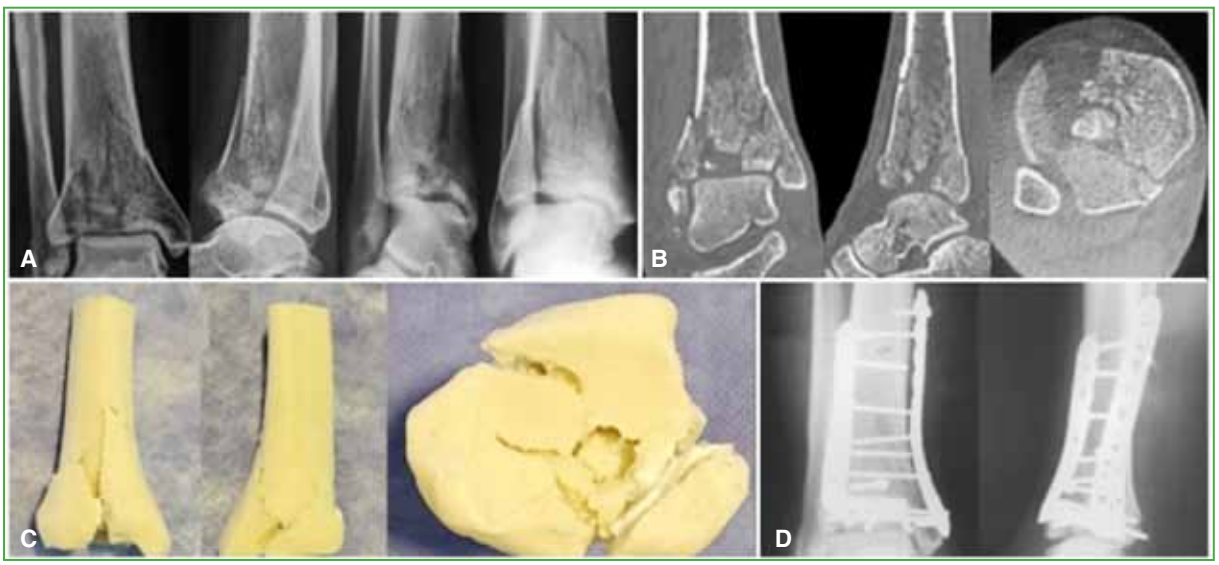

Figure 3. Clinical case 3. Radiographic and tomographic studies. The fracture of the right tibial plafond, with a complex epiphyseal-complex metaphyseal line, can be seen. **C.** 3D printed model. **D.** Radiographic images in the immediate postoperative period.

The use of the 3D model made it possible to examine the fracture lines in three dimensions and plan the reduction; to see the articular subsidence with greater precision, and to contemplate the use of a bone graft, thus optimizing surgical time frames. On the other hand, it was useful for discussing the condition and surgical procedure with the patient.

CLINICAL CASE 4

A 26-year-old woman was admitted to the outpatient clinic for idiopathic scoliosis, with a structural main thoracic curve at T3-L1 of 54° and a 30° secondary lumbar curve (Lenke IA+ classification) (Figures 4A and B).

Reduction and selective arthrodesis of the main curve was indicated. A 3D impression model was created for surgical planning (Figures 4C-E). The 3D model allowed us to better understand the deformity in three dimensions and to explain the surgery to the patient and family members. The intraoperative use allowed us to visualize the screws' entry point and orientation more clearly. There were no complications during surgery, nor loss of evoked potentials.

Figure 4. Clinical case 4. **A.** Clinical image of the patient with idiopathic scoliosis. **B.** AP and lateral radiographs of the spine. **C.** 3D printed model. **D.** Radiographic control in the immediate postoperative period. **E.** Clinical image 21 days after surgery.

CLINICAL CASE 5

A 19-year-old female with idiopathic scoliosis, with a main thoracic curve of 61° at T6-L1 and a secondary lumbar curve of 40° at L2-L5 (Lenke classification 1B+) (Figures 5A and B). Selective arthrodesis of the main curve was indicated and a 3D impression model was created (Figures 5C-E).

We used the model to illustrate the spinal defomity to the patient and her family, as well as explain the surgical procedure and its complications. At the same time, we used the design tool to identify the entry points and trajectories of the pedicle screws, as well as create a smaller printed model with holes for pin placement to aid us throughout the surgery. The surgical procedure has not yet been performed.

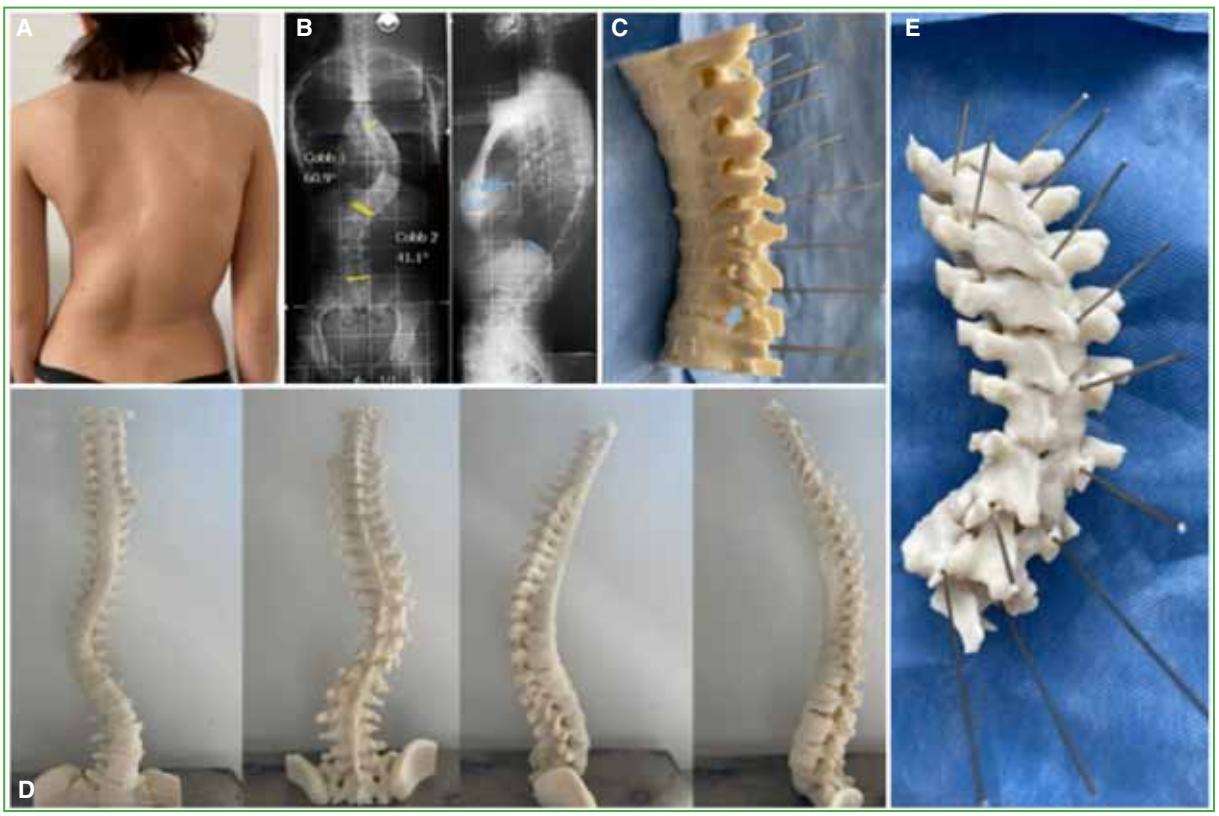

Figure 5. Clinical case 5. **A.** Clinical image of the woman with idiopathic scoliosis. **B.** AP and lateral radiographs of the spine. **C-E.** 3D printed models showing the spinal deformity in the three planes and the simulation of the screw trajectory.

CLINICAL CASE 6

A 22-year-old woman was admitted to the emergency department after an equestrian accident. An open fracture-dislocation of the right talus was found and mechanical-surgical debridement was performed, followed by reduction and immobilization with a short leg splint. Radiographs and a CT scan revealed a fracture of the right talus with a complex line involving the neck, compatible with type III of the Hawkins classification (Figures 6A and B).

Initially, reduction and osteosynthesis with a mini fragment plate were proposed because complementary studies revealed comminution in the lateral and posterior walls. However, when the 3D printed model was available and the surgical steps were planned, it was discovered that the fracture line in the posterior wall was not comminuted; therefore, the approach was adjusted to use two 3-mm and two 4-mm cannulated screws (Figures 6C and D).

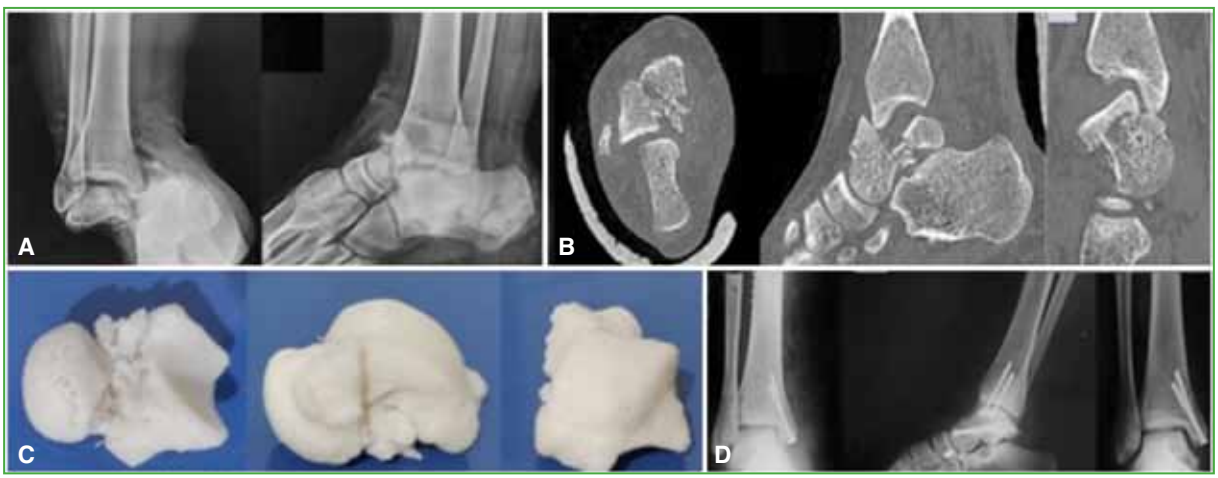

Figure 6. Clinical case 6. Radiographic and tomographic studies. Subtalar fracture-dislocation of the right foot with a neck line compatible with type III of the Hawkins classification. **C.** 3D printed model. **D.** Radiographic control in the immediate postoperative period.

DISCUSSION

Scoliosis deformities and complex articular fractures, such as those of the tibial plafond and acetabulum described in this article, pose a surgical challenge due to their three-dimensional structural complexity. 3D printing technology allowed us to perform an accurate simulation of the anatomical changes in real size, which facilitated planning with a degree of precision that is not possible with conventional instruments, in addition to deepening anatomical knowledge. The reduction achieved was more precise because we had a three-dimensional replica of the affected region.[9]

It is clear that using 3D models reduces surgical times, but image processing and printing require several hours. The time necessary to create it ranges between 5 to 72 hours, which may limit its application in an acute trauma scenario, in addition to requiring economic, human, and technological resources.

Currently, there are few prospective and comparative scientific studies examining the relationship between the use of 3D printing and the considerable benefits for the patient and surgical team, such as shorter surgery times or fewer intra-operative complications. However, we believe that the application of 3D printing in Orthopedics and Traumatology will result in significant advancements in the field.

CONCLUSION

As our experience illustrates, the rise of 3D printing in Orthopedics and Traumatology allow us to better understand complex fractures and deformities, as well as improve pre-surgical planning. There are yet insufficient studies evaluating the significant benefits of this tool for both the patient and the medical team, such as reduced surgical times, intraoperative blood loss, and radiation exposure.

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Hypothenar Hammer Syndrome. Case Report

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ABSTRACT
Hypothenar hammer syndrome is a thrombosis of the ulnar artery in Guyon's canal induced by repeated trauma. It is a rare disorder that can be diagnosed with an extensive medical history and physical examination, and confirmed by vascular studies. Management options include medical treatment and reconstructive surgery. The aim of this article is to provide a brief overview of this disorder and to discuss the case of a 45-year-old patient who developed paresthesias and signs of hypoperfusion of the fourth and fifth fingers following multiple injuries to the hypothenar eminence. The Allen test revealed the absence of vascularization in the ulnar artery, and thrombosis was verified by Doppler ultrasound and angiotomography. The thrombosed portion was excised, and Guyon's canal was cleared. The evolution was satisfactory; no signs of ischemia were found, and paresthesias improved. Follow-up was performed for 1 year.
Keywords: Hammer; hypothenar; thrombosis; aneurysm; artery; ulnar.
Level of Evidence: IV

Síndrome del martillo hipotenar. Presentación de un caso

RESUMEN
El síndrome del martillo hipotenar es la trombosis de la arteria cubital en el canal de Guyon causada por traumatismos repetitivos. Se trata de un cuadro infrecuente que se diagnostica mediante la detallada valoración de los antecedentes y el examen físico, y se confirma con estudios vasculares. El manejo incluye desde tratamiento médico hasta cirugía reconstructiva. El objetivo de este artículo es brindar una breve reseña de esta enfermedad y presentar el caso de un paciente de 45 años, con parestesias y signos de hipoperfusión del cuarto y quinto dedos luego de múltiples traumatismos en la eminencia hipotenar. En la prueba de Allen, se detectó ausencia de vascularización de la arteria cubital, y la trombosis se confirmó mediante ecografía Doppler y angiotomografía. Se resecó el fragmento trombosado y se liberó el canal de Guyon. La evolución fue satisfactoria, no se observaron signos de isquemia y las parestesias mejoraron. Se realizó un seguimiento por 1 año.
Palabras clave: Martillo; hipotenar; trombosis; aneurisma; arteria, cubital.
Nivel de Evidencia: IV

INTRODUCTION

Hypothenar hammer syndrome is thrombosis of the ulnar artery associated with repetitive trauma to the hypothenar eminence.

Guttani and Von Rosen described the first case in 1934 as a post-traumatic thrombosis of the ulnar artery at the distal level discovered after an operation in an industrial worker, but it was not until 1970 that Conn et al. termed the lesion *hypothenar hammer syndrome* (HHS).[1-4] It is commonly seen in people who use their palms as hammers, continuously pounding or compressing the ulnar artery against the hook of the hamate in Guyon's canal, where the artery is most vulnerable.

Typically, HHS affects men with an average age of 40 years,[2] on the dominant hand in 53-93% of cases,[5] and in occupational settings where the worker uses the hypothenar portion of the hand as a tool for hammering, pushing, or squeezing hard objects. People at greatest risk for this disease include metal workers, auto mechanics, lathe

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operators, machinists, miners, sawmill workers, butchers, bakers, bricklayers and carpenters. Cases have also been described in athletes who practice field hockey and athletics. Occasionally, a single episode of significant trauma may be the cause of HHS.[1-3,6]

Guyon's canal is formed between the hamate and pisiform bones with only a thin roof above.[7] Thus, there is an approximately 2-cm section of the ulnar artery that is very vulnerable to acute and chronic trauma.[8] Frequent blunt trauma to the hypothenar eminence compresses the unprotected ulnar artery against the hook of the hamate and triggers a vasospasm of the artery. Continued trauma causes damage to the tunica intima, which favors platelet aggregation and thrombus formation. Distal embolization of the digital arteries exacerbates ischemia,[1,7] a phenomenon described in up to 50% of patients.[9] Less commonly, repetitive blunt trauma results in ulnar artery aneurysm formation. The superficial palmar branch of the ulnar artery provides the main blood supply for most of the fingers and, in 31% of patients, the superficial arch arises entirely from the ulnar artery. In 16-22% of patients, the superficial arch is incomplete.[2]

It is not uncommon for the initial injury to appear trivial and, consequently, to be ignored,[2] as it is a rare medical condition that affects less than 1% of the general population.[10] In one study, 7% of 330 factory workers had HHS.[6]

Diagnosis is primarily clinical, and therefore requires a high index of suspicion. Patients usually present with hypothenar pain, cold and pale fingers (3rd, 4th, and 5th), color changes, trophic lesions due to digital ischemia (findings in the fingertips, such as splinter hemorrhages, ulcerations, and gangrene), paresthesias in the ulnar nerve territory, and, on rare occasions, a palpable mass in the hypothenar eminence due to the formation of an aneurysm over this site followed by a thrombus.[1,3,6,11] The absence of the triphasic color change found in classic Raynaud's phenomenon, which does not affect the thumb, provides a diagnostic clue.[11] Hypothenar hypersensitivity and an abnormal Allen test (slow or complete absence of filling of the hand when the radial artery is occluded) help to confirm the diagnosis.[2,3] Of course, rheumatoid arthritis, Buerger's disease, thoracic outlet syndrome, Raynaud's phenomenon, lupus erythematosus, and scleroderma are all disorders that can cause many of these symptoms and should be considered as well.[4]

Angiography is considered the gold standard for diagnosis, often showing a characteristic "corkscrew" appearance of the affected portion of the artery as it courses along the hook of the hamate.[2,11] While angiography can show detailed arterial anatomy and is superior to other diagnostic studies in patients with a smaller ulnar artery or an occlusion in the most distal part of the fingers, it is an invasive procedure that may not be available in all medical facilities. Doppler ultrasound, magnetic resonance angiography and CT angiography are also useful tests to confirm the diagnosis.[1]

Treatment may vary according to the intensity and speed of onset of symptoms.[1] In mild cases, it involves lifestyle changes (quitting smoking, wearing gloves while working), medications such as calcium channel blockers (nifedipine, diltiazem), antiplatelet agents or anticoagulants, and pentoxifylline to decrease blood viscosity. In more severe cases or when conservative treatment fails, surgery may be required, which consists of arterial ligation (assuming an intact radial/palmar arch), resection of the thrombosed arterial segment or aneurysm with end-to-end anastomosis, and resection and vascular reconstruction with a vein or artery graft or thrombolysis.[1-3,11]

The purpose of this article is to provide a brief overview of this disease and to report a clinical case of acute-onset HHS caused by ulnar artery thrombosis, which was treated with excision of the affected segment.

CLINICAL CASE

A 45-year-old right-handed man with no significant medical history, a mechanic by trade, presented to the Emergency Department with numbness in the 4th and 5th fingers of his left hand after a day of work in which he impacted with the heel of his hand on multiple occasions while working, four days prior to the consultation. He did not report smoking or alcohol consumption, nor a family history of hyperviscosity syndrome, nor previous sensitivity disorders.[3,9]

He had no deformities or swelling of the fingers, hand or wrist. Passive and active range of motion was complete. He presented with severe pain (9 out of 10 on palpation) in the hypothenar eminence and a small pulsatile hypothenar mass was observed.[5] Paresthesias were detected at the palmar level of the 5th and 4th fingers, and sensation in the dorsum of the hand was preserved. He had no signs of median nerve compression in the carpal tunnel, negative Tinel's sign in the cubital tunnel, and positive in Guyon's canal. Finger separation against resistance (interosseous

muscles) was not limited, and Froment's sign was absent.[1] Raynaud's phenomenon was observed in the 4th and 5th fingers (without erythematous phase)[2] with distal cyanosis, no symptoms in the thumb and index finger, and pallor in the middle finger (Figure 1). All three ulnar fingers were cold. Allen's test was positive in the left wrist, without vascularization of the ulnar artery.[12]

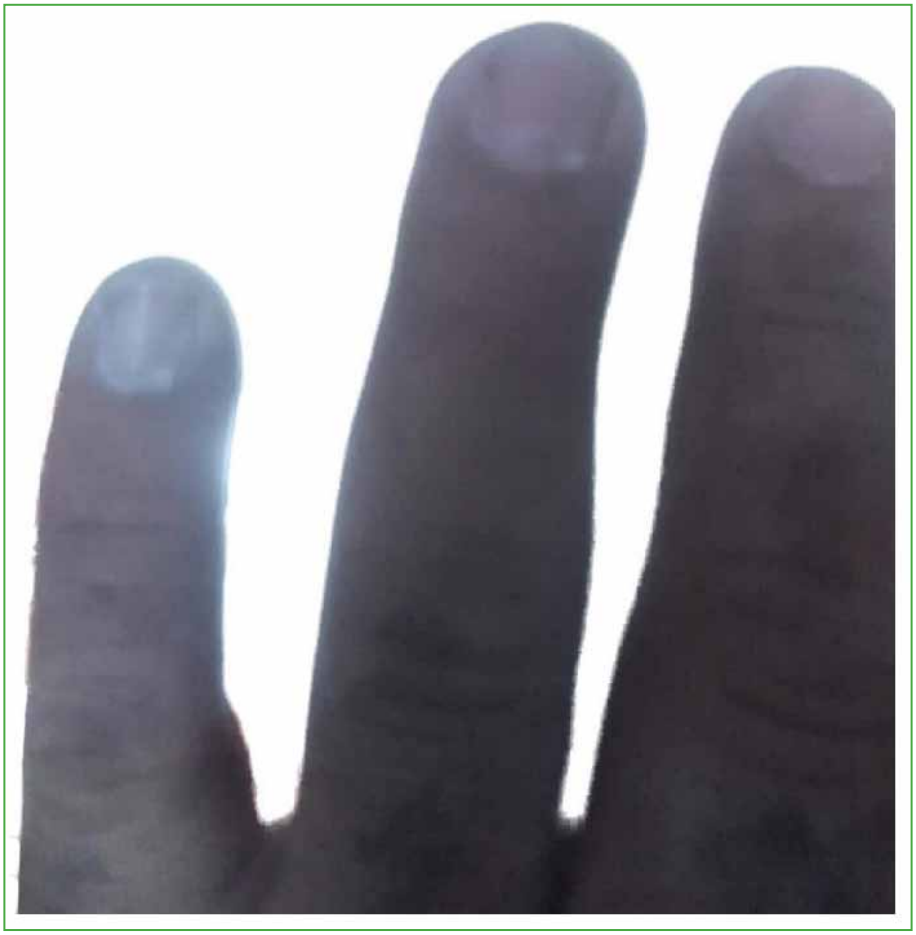

Figure 1. Image of the first day of acute symptomatology. Signs of ischemia in the 4th and 5th fingers.

Complementary studies

Radiographs and CT scans were negative (no hamate fracture).[3] Additional blood samples were taken to rule out rheumatic and collagen diseases or vasculitis. Likewise, the evaluation by the Rheumatology physicians did not detect any disease.

An electromyography of the upper limb showed decreased conduction velocity of the left ulnar nerve in Guyon's canal, with increased distal latency velocity, suggesting ulnar neuropathy at the left wrist.[10]

A bilateral arterial Doppler scan of the upper limbs performed during the initial days of hospitalization revealed no atheromatous calcifications of the ulnar artery at the level of Guyon's canal, but did reveal tunica intima thickening and distal monophasic flow (Figure 2). CT angiography was requested and confirmed the diagnosis (Figure 3), as well as the presence of the superficial palmar arch (Figure 4).

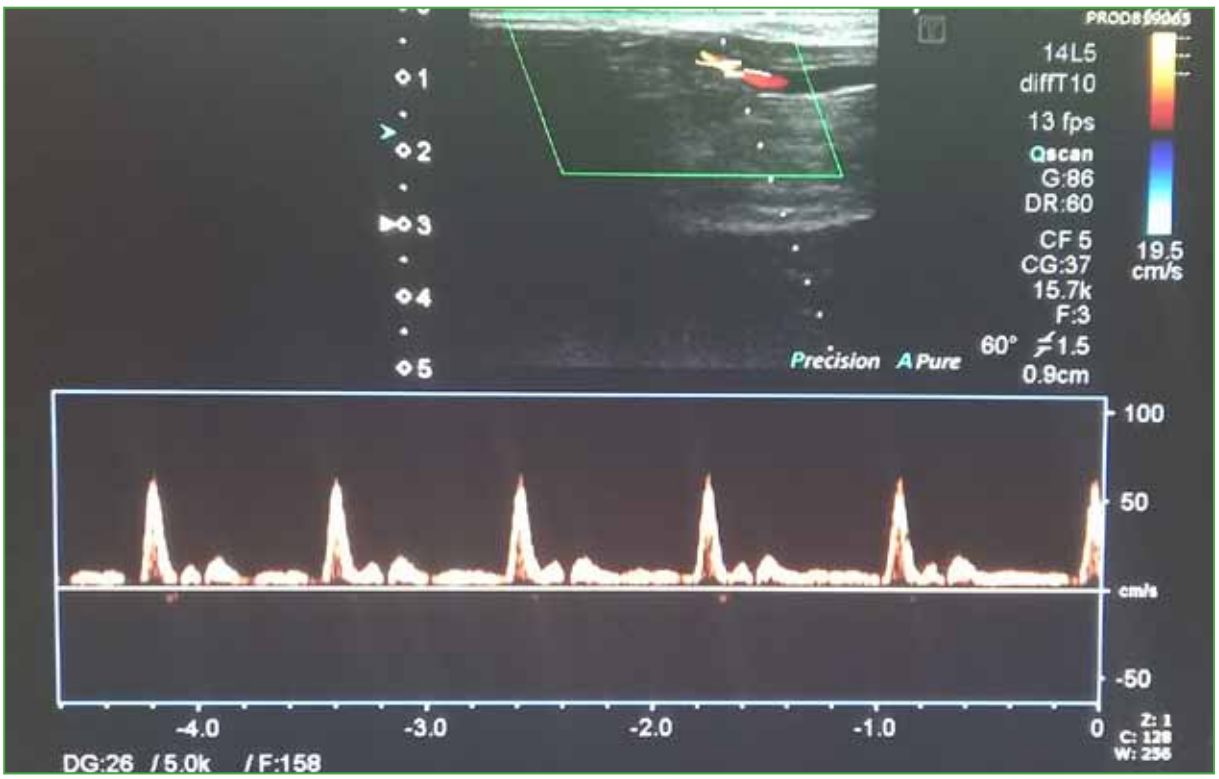

Figure 2. Doppler ultrasound of the ulnar and radial arteries. Decreased flow is observed in the ulnar artery, which is monophasic in the distal region of the wrist.

Figure 3. CT angiography of the left hand. Common palmar digital arteries and princeps pollicis artery (red arrows). The deep palmar arch is intact (green arrow).

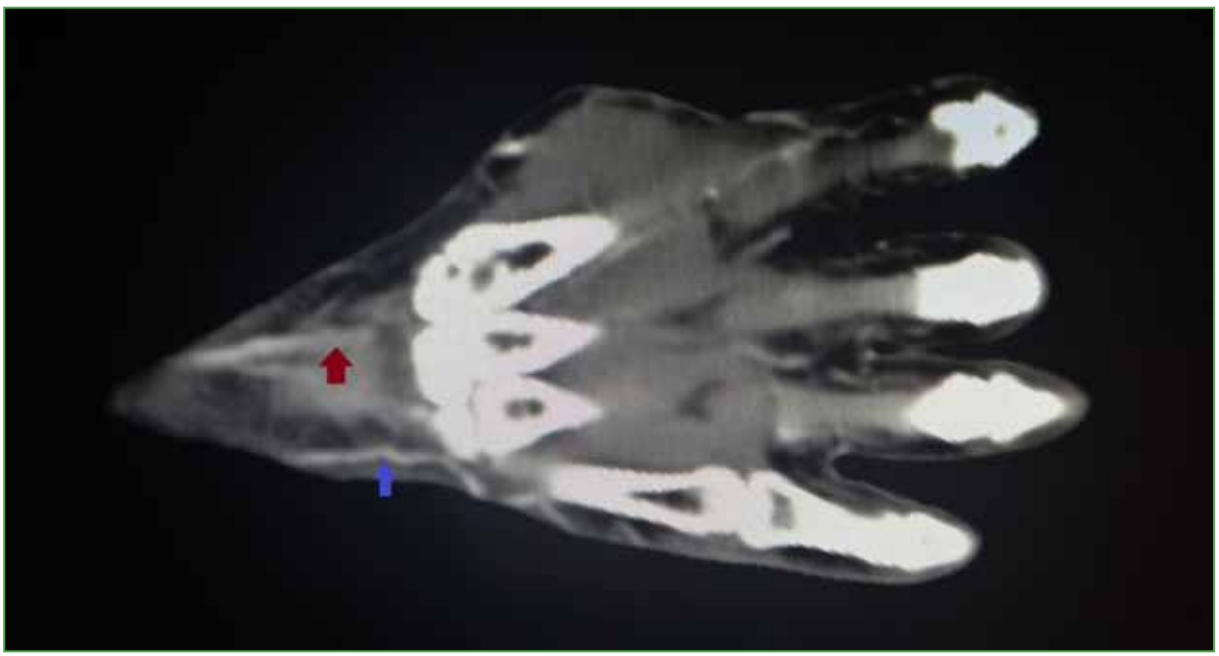

Figure 4. CT angiography of the left hand. Ulnar artery with stenosis and flow that stops in Guyon's canal (blue arrow). Radial artery with good diameter and flow (burgundy arrow).

Medical treatment

The patient was hospitalized for further studies, control, and pharmaceutical treatment. He was given cilostazol 100 mg/day, nimodipine 30 mg, every 6 h; enoxaparin 80 mg, subcutaneously, every 12 h; aspirin 100 mg/day, pregabalin 75 mg/day, ketorolac 60 mg/day and tramadol 100 mg/day.

He was monitored for one week: signs and symptoms improved, pain decreased to 2 out of 10, finger perfusion improved, with reduced capillary refill time. The patient was discharged with outpatient management (Figure 5).

Figure 5. Images taken at the time of discharge. Improved coloration and capillary filling.

At the time of discharge, Allen's test was positive for the ulnar artery in the left wrist, Tinel's test was positive in Guyon's canal and he had paresthesias in the volar region of the ulnar border of the ring finger and in the pinkie finger; for this reason, surgical treatment was decided.

Surgical resolution

The surgery was performed as an outpatient procedure under axillary brachial plexus block, with the patient in dorsal decubitus and the arm on a surgical table. A distal antebrachial and palmar approach was made to the ulnar artery, the artery was identified proximally in the healthy area, and the carpal and Guyon's canals were opened. In the ulnar artery, a tortuous tract of approximately 2 cm was identified, containing a thrombus and an aneurysm of about 1 cm (Figure 6). The ulnar nerve was divulsed (both the motor branch and the sensory branch of the ulnar nerve). The thrombosed fragment was resected.[2] The ischemia tourniquet was removed and a good capillary refill was verified.[1] The skin was closed and an adequate local temperature of the fingers was verified, with capillary refill time <2 seconds.

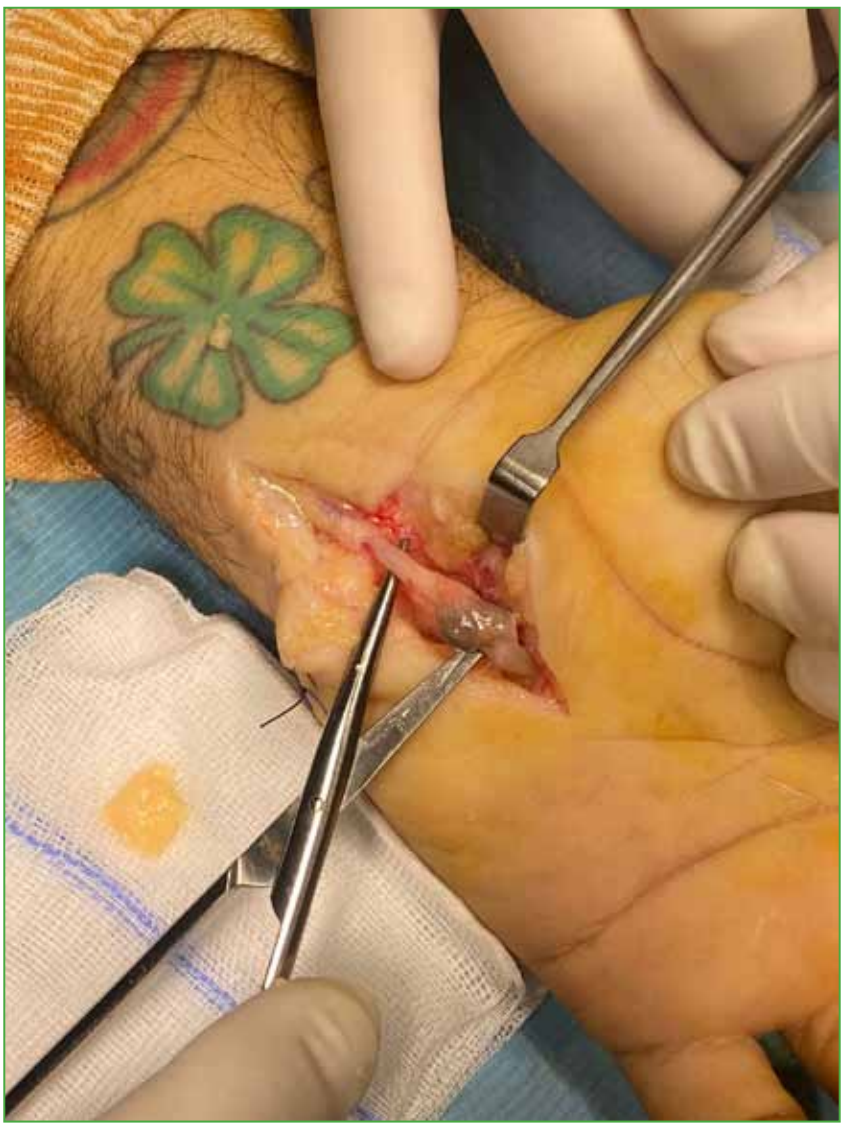

Figure 6. Ulnar artery dissection with thrombosis and aneurysm.

The paresthesias of the 4th and 5th fingers disappeared immediately after surgery. In the postoperative period, the patient had a good evolution, with no signs of infection and a clear improvement of pain on palpation of the hypothenar eminence. The sutures were removed after 15 days. The patient was prescribed 20 sessions of physical therapy. Three months after surgery, the patient had no symptoms and resumed his work activities. Follow-up lasted a year (Figure 7).

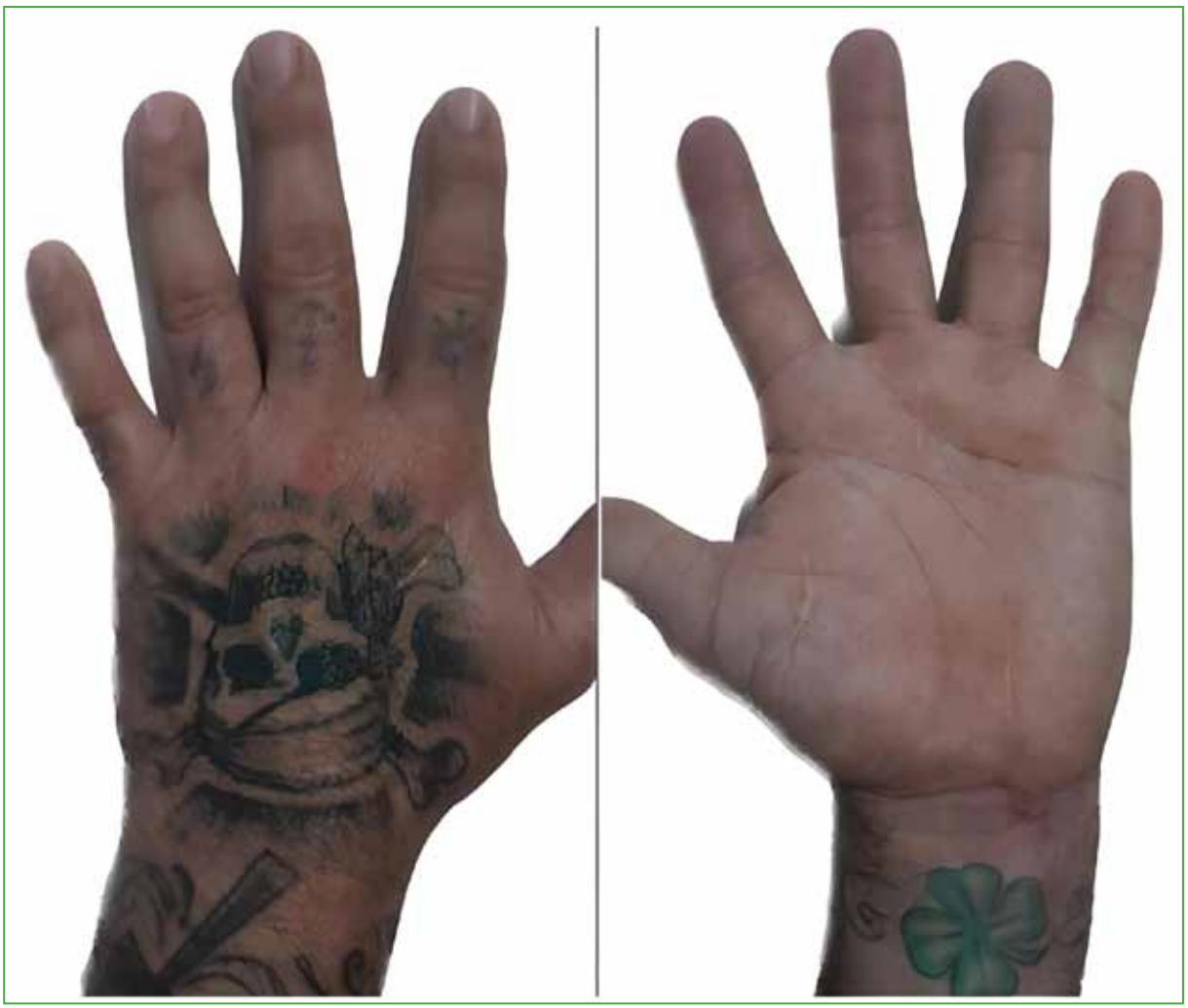

Figure 7. Images taken one year after the intervention. Full recovery is observed.

One year after surgery, the patient had a capillary refill time of less than 2 seconds and normal mobility and sensitivity. He had no pain or trophic skin lesions. He manifested hyperalgesia discomfort with exposure to cold.

DISCUSSION

HHS is an infrequent cause of digital ischemia, accounting for <2% of the more than 1300 cases presenting to a vascular surgery center with hand-related symptoms.[1] The true incidence is not exact since chronic patients may have flow compensation from the radial artery, resulting in the formation of collateral circulation. For this reason, the speed of onset of signs and symptoms is fundamental to define the severity of the condition.[11]

Given the low incidence of the condition and the possibility of a subclinical presentation with few symptoms due to the aforementioned flow compensation by the radial artery, reaching an early diagnosis is difficult. Despite these difficulties, once diagnosed, different treatment algorithms are available in published research studies.[1,2]

Based on our experience, we suggest the following treatment possibilities:

1. *Asymptomatic or mildly symptomatic patients with no paresthesias in the ulnar region* (with a palpable mass and hypothenar eminence or sporadic pain, with occlusion or subocclusion of the ulnar artery, but without signs of ischemia). Medical treatment.[2,11,12]

2. *Asymptomatic or mildly symptomatic patients with paresthesias in the ulnar region* (with a palpable mass and hypothenar eminence or sporadic pain, with occlusion or subocclusion of the ulnar artery, but without signs of ischemia). Surgical treatment with Guyon's canal release and resection and ligation of the thrombosed artery fragment.[2,11,12]

3. *Symptomatic patients with symptoms of digital ischemia.* Initiate medical-pharmacological treatment. If there is clinical improvement, proceed with points 1 or 2 of the algorithm. If there is no improvement, proceed with vascular reconstruction surgery or end-to-end anastomosis.[2,3,11]

CONCLUSIONS

HHS is often misdiagnosed or diagnosed late, partly because of compensation by the radial artery, but also because it is an uncommon condition. A meticulous clinical history, including an assessment of occupational or sports injuries, a thorough physical examination, and a high index of suspicion are required to make the diagnosis.

In asymptomatic cases or those with mild symptoms, observation, pharmacotherapy and risk factor management are indicated. When the evolution is more torpid, the signs and symptoms are of rapid onset, and medical treatment provides little relief, as in our patient, surgery resolves the nerve compression that produces pain and paresthesia. The treatment of choice if there is vascular ischemia is end-to-end anastomosis or vascular reconstruction with vein grafting.

With this case, we illustrated the relevance of including HHS in the differential diagnosis of patients who present in a clinical setting similar to our professional practice.

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Fat Embolism Syndrome Secondary to Short Bone Fracture: Case Presentation

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ABSTRACT

Introduction: We present the clinical case of a 15-year-old male who sustained fractures to the short bones of his right foot as a result of a traffic accident. After 24 hours of evolution, he was admitted for dyspnea, desaturation, an objective febrile peak, and the development of respiratory failure. Given the clinical suspicion of fat embolism syndrome, pulmonary CT angiography was requested, which confirmed the diagnosis. This is a rare finding in patients with this type of fracture. The initial treatment included close monitoring in the intensive care unit, supportive measures such as supplemental oxygen, respiratory therapy, and surgical fracture management. The patient's clinical progression was adequate, and the respiratory condition resolved completely. **Conclusion:** Fat embolism syndrome resulting from short bone fractures is a rare condition; therefore, it is necessary to have a high level of diagnostic suspicion, not only in the most common scenarios, but also in these unusual and challenging contexts, which allows for its early detection and, as a result, timely management, which has a positive impact on clinical outcomes and reduces the risk of long-term sequelae.

Keywords: Fat embolism; bone fractures; respiratory insufficiency.

Level of Evidence: IV

Síndrome de embolia grasa secundario a fracturas de huesos cortos: Presentación de casos

RESUMEN

Se presenta el caso clínico de un varón de 15 años con fracturas de huesos cortos del pie derecho como consecuencia de un accidente de tránsito. Tras 24 h de evolución, ingresa con disnea, desaturación, pico febril objetivo y posterior desarrollo de insuficiencia respiratoria. Ante la sospecha clínica de síndrome de embolia grasa, se solicita una angiotomografía pulmonar que confirma el diagnóstico. Se trata de una entidad inusual en pacientes con este tipo de fractura. El tratamiento inicial consistió en vigilancia estrecha en la unidad de cuidados intensivos, medidas de soporte con oxígeno suplementario, terapia respiratoria y manejo quirúrgico de las fracturas. La evolución clínica del paciente fue adecuada y el cuadro respiratorio se resolvió por completo. **Conclusiones:** El síndrome de embolia grasa secundario a fracturas de huesos cortos es un cuadro infrecuente; por lo tanto, es preciso tener un alto grado de sospecha diagnóstica, no solo en los escenarios más comunes, sino también en este tipo de contextos inusuales y retadores, que permita su identificación temprana y, de esta forma, implementar un manejo oportuno y generar un impacto favorable en los desenlaces clínicos y en la disminución del riesgo de secuelas a largo plazo.

Palabras clave: Embolia grasa; fracturas; insuficiencia respiratoria.

Nivel de Evidencia: IV

INTRODUCTION

Fat embolism is the presence of fat globules in the systemic circulation, mainly in sites of increased vascularization, such as the lungs and brain, while fat embolism syndrome refers to the clinical manifestations that appear as secondary complications of fat embolism.[1]

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Fat embolism is much more frequent and, in general, its course is benign compared to that of fat embolism syndrome, which can generate high morbidity and mortality. It is more common in men between 10 and 40 years of age, and the estimated incidence ranges from 1% to 30%, depending on the diagnostic criteria used, pathological history and clinical context. It is not commonly associated with orthopedic trauma, particularly fractures of long bones such as the femur and tibia, but it has been reported in patients with fractures of short bones as well as cases of non-orthopedic ailments or contexts such as pancreatitis, sickle cell anemia crisis, bone marrow transplantation, or aspiration and liposuction.[2]

Due to its heterogeneous presentation and non-specific symptoms, the diagnosis is complex and exclusionary, relying on a combination of physical examination findings, laboratory testing, imaging studies, and the use of multiple scales as diagnostic aids.[3]

Treatment focuses on implementing prophylactic behaviors, such as immobilization and early surgical fixation, or, if that fails, managing the underlying cause, symptom control, and supportive measures, such as ventilatory support.[4]

The aim of this case report is to highlight the high diagnostic suspicion of fat embolism syndrome in this scenario, manifested as respiratory failure in an atypical context, such as short bone fractures of the foot, and its timely therapeutic approach provided by early surgical treatment associated with clinical care, hemodynamic and supportive measures with adequate evolution and complete resolution of the picture.

CLINICAL CASE

A 15-year-old male, student, with no significant medical history, suffered a motorcycle accident and sustained trauma to the right lower limb. Initially, he was taken to the local low complexity hospital, where he underwent debridement of the wound in the right foot, and was left under clinical observation for pain control. Twenty-four hours after the trauma, he had tachycardia, fever and desaturation.

After 30 h, he was transferred and admitted to our high complexity institution, with vital signs and the following parameters: blood pressure 114/67 mmHg, heart rate 123 beats/min, respiratory rate 21 breaths/min and oxygen saturation of 82%, so he was administered supplemental oxygen by nasal cannula and reached saturation goals >90%, with no clinical signs of respiratory failure.

The initial physical examination revealed edema on the dorsum of the right foot, mostly in the region of the first metatarsal to the distal phalanx of the hallux, with a wound on the medial aspect and no active bleeding or distal neurovascular deficit. There was no evidence of traumatic brain injury, thoracoabdominal trauma, or other trauma-related symptoms or pathology findings.

Basic laboratory tests revealed no anemia, leukocytosis, renal failure, or electrolyte imbalance, and arterial gases were free of acidosis, hypoxia, or hyperlactatemia.

Radiographs were requested to define the bone involvement, and a closed intra-articular fracture of the distal phalanx of the hallux, a comminuted open fracture of the first metatarsal, and an avulsed bone fragment in the dorsum of the navicular were discovered (Figure 1). Consequently, he was immobilized with a short leg splint and received antibiotic therapy with cefazolin 2 g intravenously every 8 hours for 72 hours, as per the institutional protocol. The Orthopedic Service physicians scheduled a cleaning, debridement and surgical correction of the fractures.

On the same day, he was evaluated by the Internal Medicine physicians who, in view of the clinical picture, requested a pulmonary CT angiography. The official report from Radiology ruled out pulmonary thromboembolism, consolidating foci, contusions, pulmonary lacerations, pneumothorax, pleural effusion or atelectasis, but noted patchy ground-glass opacities, some of nodular appearance, mainly involving the left upper and right lower lobes and, to a lesser extent, the subpleural region of the right apex, confirming fat embolism (Figure 2).

Within 12 hours of admission, the patient displayed clinical deterioration, increased oxygen requirement, desaturation, and hypoxemic respiratory failure, so it was indicated to continue support management with oxygen therapy and respiratory incentive. The patient was immediately transferred to the Intensive Care Unit, and an immediate surgical procedure was authorized, which was performed without complications and involved cleaning and debridement of the wound in the foot, bone curettage, and open reduction and osteosynthesis of the right first metatarsal (Figure 3).

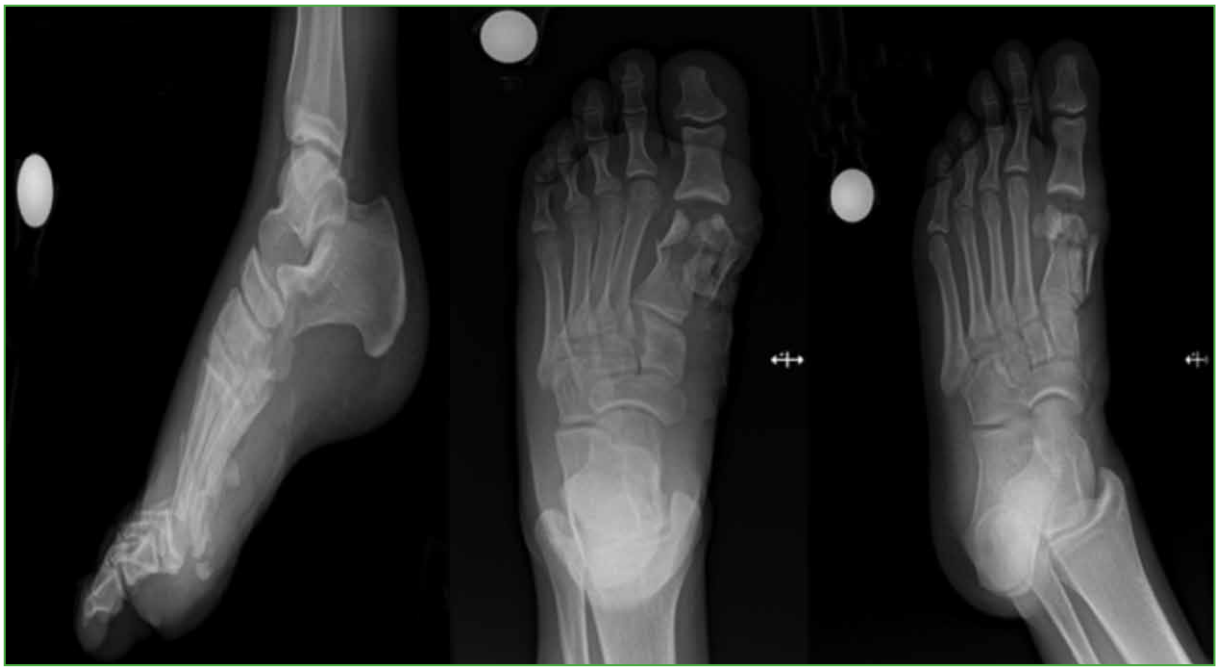

Figure 1. Anteroposterior, lateral and oblique radiographs of the right foot showing a closed intra-articular fracture of the distal phalanx of the hallux, a comminuted fracture of the first metatarsal and an avulsed bone fragment on the dorsum of the navicular bone.

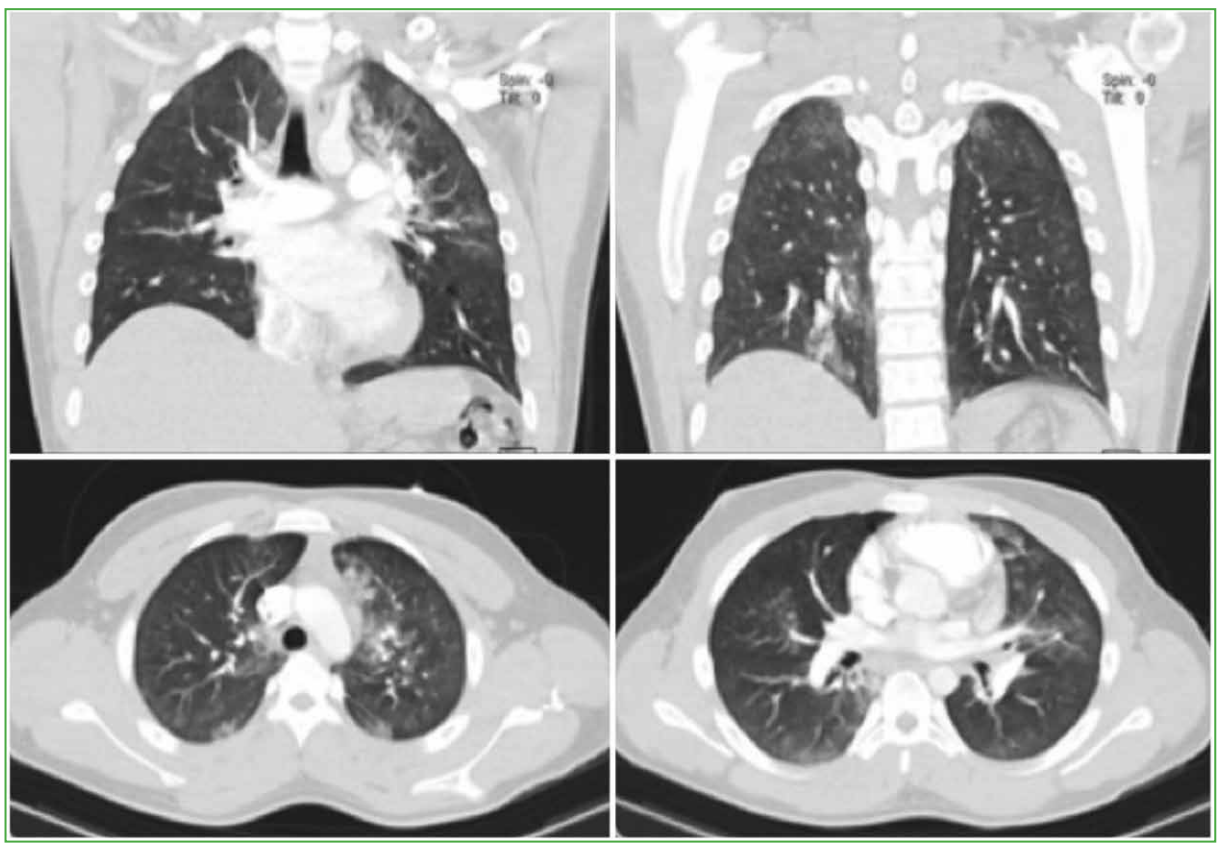

Figure 2. Pulmonary CT angiography with findings of fat embolism syndrome.

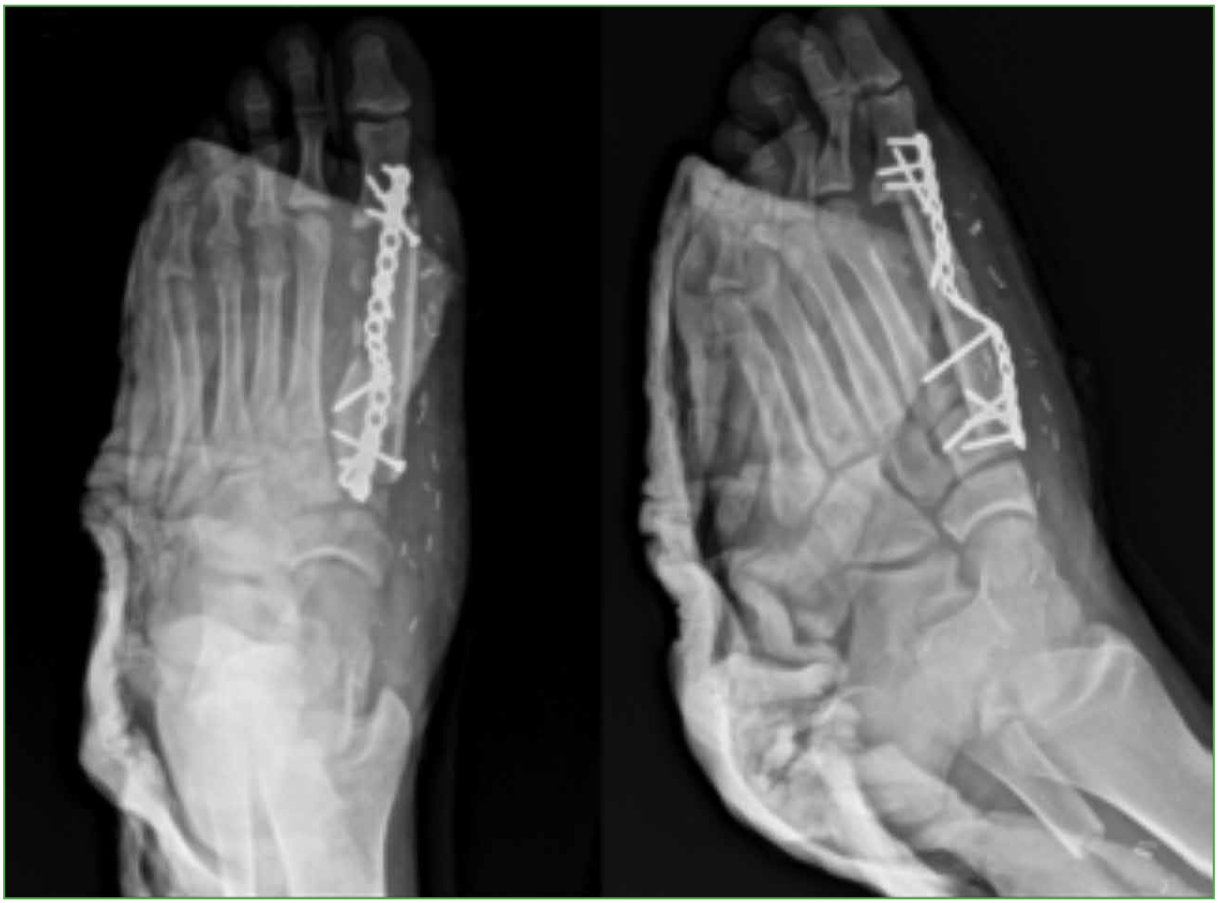

Figure 3. Anteroposterior and oblique radiographs of the right foot showing the postoperative outcome.

The patient evolved adequately following the operation. He continued with analgesia, which resulted in satisfactory pain control. He made progress with nutrition. He progressed with respiratory therapy and incentive, and oxygen reduction was initiated, with good tolerance until discontinuation was accomplished on day four.

The patient was transferred to a general ward without clinical or respiratory deterioration, with normal hemodynamic variables; symptoms resolved seven days after hospital admission.

DISCUSSION

Fat embolism is frequent in patients with long bone and pelvic fractures, but most do not present with signs suggestive of fat embolism syndrome, which is considered a diagnosis of exclusion. It manifests with respiratory and neurological symptoms, as well as a skin rash, but its presentation is heterogeneous and non-specific, and not everyone develops this clinical triad, so other factors are considered, such as laboratory test results, imaging studies, and diagnostic criteria, while keeping in mind that no finding is pathognomonic of the disease.[5]

In this case report, it is demonstrated how only respiratory symptoms and pulmonary involvement evidenced by increasing hypoxemia until respiratory failure, as well as CT angiography findings, led to the diagnosis of fat embolism syndrome.

When examining the current identification criteria, none are standardized for systematic application or provide diagnostic confirmation, but the combination of the Gurd and Wilson criteria, as well as the Lindeque criteria, is widely accepted.[1]

In the literature review, only two meta-analyses evaluating the clinical characteristics of patients with fat embolism syndrome stand out: one limited to a specific subpopulation of patients who develop the entity after musculoskeletal trauma and another in which the disease manifests itself due to any cause. In both, it was concluded that, although it is a rare condition, it was more frequently associated with fractures of long bones, mainly of the femur and, secondarily, of the tibia and fibula. [6,7]

Likewise, there are some case reports that are anatomically close to our case. Ramirez and Dawkins published the appearance of the syndrome in a 36-year-old man with fracture-dislocation of the right talus and fracture of the head of the fourth and fifth right metacarpals due to a traffic accident. 48 h after admission, he began with dyspnea, desaturation, right pleuritic pain, tachypnea and tachycardia, without neurological deficit, so he was transferred to the Intensive Care Unit, where a thorax CT scan with contrast showed bilateral alveolar infiltrates of basal predominance suggestive of fat embolism. The patient had an adequate clinical evolution with supportive measures.[8]

In 2016, Gonzalez Murillo et al. described a 24-year-old patient with an open right calcaneal fracture caused by a gunshot wound. 24 h after the trauma, he started with fever, restlessness, tachypnea and desaturation, and it was decided to administer corticosteroids and oxygen therapy in a high dependency unit. The diagnosis was confirmed with a thorax CT scan that revealed a patchy, bilateral and diffuse ground-glass pattern, with small areas of alveolar and distal bronchiolar involvement, predominantly peripheral.[9]

In general, the pillars of treatment are similar and none is specific to the entity; they are based on early diagnosis, initial stabilization measures, hemodynamic and respiratory support, and correction and management of the underlying cause. In cases involving fractures, it is critical to execute behaviors such as immobilization, early surgical correction, and finally rehabilitation.[4]

CONCLUSIONS

Fat embolism syndrome secondary to short bone fractures is a rare condition that requires a high degree of diagnostic suspicion, not only in the most common scenarios, but also in this type of unusual and challenging contexts. Its early detection and timely management generates a favorable impact on clinical outcomes and reduces the risk of long-term sequelae.

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Anterior Tibial Tubercle Avulsion Fracture in Pediatric Patients. Case Report

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ABSTRACT

Epiphysiolysis of the anterior tibial tubercle in adolescents accounts for 1% of physeal injuries and 3% of proximal tibial fractures, and it may involve the physis; therefore, they require a proper diagnosis and treatment to avoid complications. **Objective:** To report a clinical case, compare it with similar published cases, examine the differences, and, based on our experience, arrive at a resolution. We present a 13-year-old male who consulted after suffering direct trauma to his right knee while running in sports practice one month earlier. Radiography revealed epiphysiolysis due to avulsion of the anterior tibial tubercle (Odgen IIIA and Jones III), thus the patient underwent open reduction and internal fixation with two partially-threaded cannulated screws and washers. A plaster cast was placed and removed after six weeks to begin rehabilitation. Because healing and return to regular activity were quick, AP and lateral radiographs were obtained for diagnosis and a CT scan for surgery planning. Then, open reduction and internal fixation with two cannulated screws surrounding the physis was performed, although the patellar tendon was explored first since it had a higher risk of invagination within the fracture line. **Conclusion:** Although there is no consensus on diagnosis and treatment due to the small number of reported cases of this injury, which is increasing due to the growing popularity of sports among young people, it is advisable to suspect it in young patients who sustain knee injuries with extension limitation.

Keywords: Pediatric patient; knee; tibial tubercle avulsion; osteosynthesis; patellar tendon.
Level of Evidence: IV

Fractura por avulsión de la tuberosidad anterior de la tibia en pacientes pediátricos. Reporte de caso

RESUMEN

Introducción: Las epifisiólisis de la tuberosidad anterior de la tibia en adolescentes representan el 1% de las lesiones fisarias y el 3% de las fracturas de la tibia proximal, y pueden comprometer la fisis; por lo tanto, ameritan un diagnóstico y un tratamiento correctos para evitar complicaciones. El objetivo de este artículo es comunicar un caso clínico, compararlo con casos similares publicados, analizar las diferencias y, sobre la base de la experiencia, llegar a una conclusión para su resolución. Presentamos a un varón de 13 años que consultó tras sufrir un traumatismo directo en la rodilla derecha, durante la carrera en la práctica deportiva, un mes atrás. La radiografía mostró epifisiólisis por avulsión de la tuberosidad anterior de la tibia (Odgen IIIA y Jones III), por lo que fue sometido a reducción abierta y fijación. Como la recuperación y el retorno a la actividad habitual fueron rápidos, se tomaron un par radiográfico para el diagnóstico y una tomografía para la planificación quirúrgica. **Conclusión:** Si bien no hay un consenso sobre el diagnóstico y el tratamiento por la baja cantidad de casos publicados, es conveniente sospechar este cuadro pacientes jóvenes que sufren traumatismo en la rodilla con limitación de la extensión.

Palabra clave: Paciente pediátrico; rodilla; avulsión; tuberosidad anterior de la tibia; osteosíntesis; tendón rotuliano.
Nivel de Evidencia: IV

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INTRODUCTION

Epiphysiolysis of the anterior tibial tuberosity (ATT) in adolescents accounts for 1% of physeal injuries and 3% of proximal tibial fractures.[1] The pathophysiology of this type of fracture is directly related to the ossification pattern of the knee. The physis of the ATT that connects to the tibial plateau is most susceptible to fracture between the ages of 13 and 16, as the cartilage closes from posterior to anterior. The proximal tibia has two ossification centers. The main one is located in the physis of the proximal tibia, and the secondary one is located at the level of the anterior tubercle. The closure of these centers starts from posterior to anterior and from proximal to distal; the ossification center of the anterior tuberosity is the last to close.[2] It is critical to be familiar with the differential diagnoses and potential treatment options for ATT avulsion in adolescents since, according to recent publications, it is a rare injury that is becoming more common as young people participate in more sports. ATT fractures in adolescents are typical childhood injuries that directly involve the physis and require prompt diagnosis and treatment to avoid growth complications such as genu recurvatum, loss of flexion-extension, patella alta, and osteonecrosis (rare).

Trauma mechanism

1. Jumping take-off. The fracture occurs in the final phase, with the knee extension, and only the tuberosity is fractured.
2. While landing from a jump. The knee is in flexion, thus fracturing both.
3. Forced extension against resistance. It causes avulsion of the tuberosity.
4. Forced flexion. It causes avulsion of the tuberosity.[3]

The most commonly used classifications are:

Odgen classification (Figure 1):

- Type IA: Fracture line leads through the ossification center of the tuberosity.
- Type IB: Same as type IA, but with displacement.
- Type IIA: Fracture-separation of the entire tuberosity.
- Type IIB: Same as type IIA, but with comminution of the ossification center.
- Type IIIA: Fracture line extends to the femorotibial joint with some displacement.
- Type IIIB: Same as type IIIA, but with comminution.[4] (types IA, IB and IIA: conservative treatment), (types IIB, IIIA and IIIB: surgical treatment)

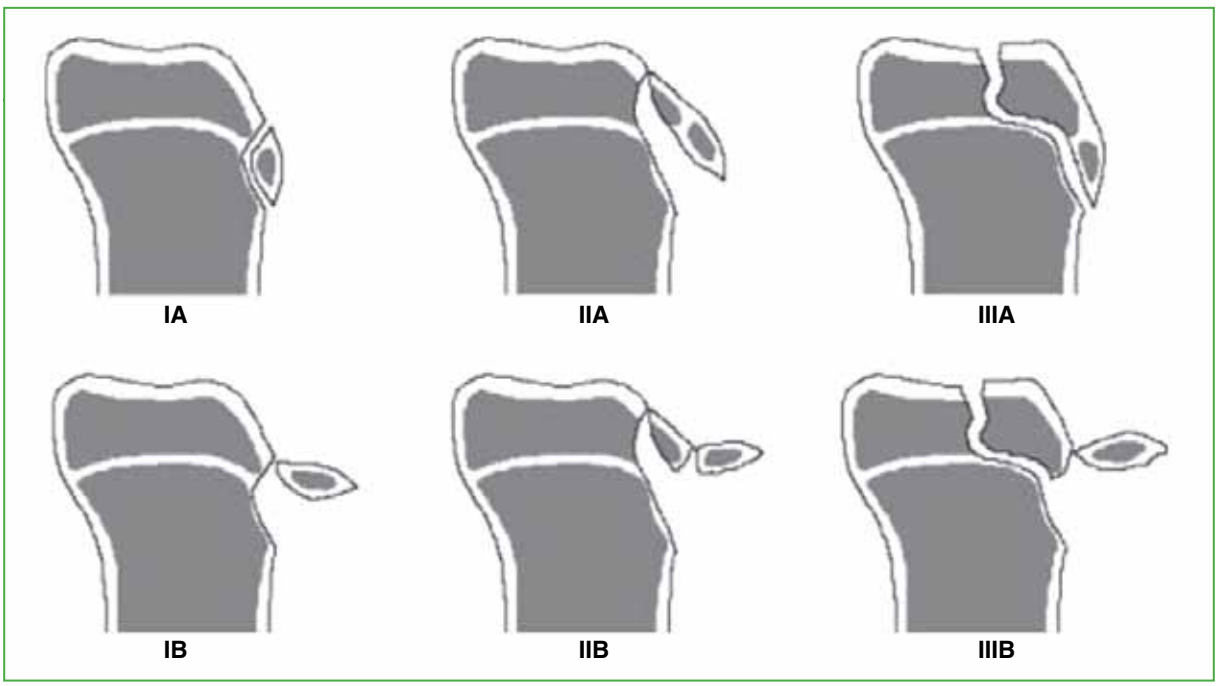

Figure 1. Odgen's classification of avulsion fractures of the anterior tuberosity of the tibia.

Watson-Jones classification (Figure 2):

- Type I: Fracture-separation of the secondary ossification center of the tubercle near the posterior border of the insertion of the patellar tendon.
- Type II: Fracture-separation between the primary and secondary ossification centers of the proximal tibial epiphysis.
- Type III: Same as Salter and Harris Type III. The line of separation follows an ascending path through the primary ossification center of the proximal tibial epiphysis, affecting the joint.
- Types A and B are modifiers according to the degree of displacement and fragmentation.

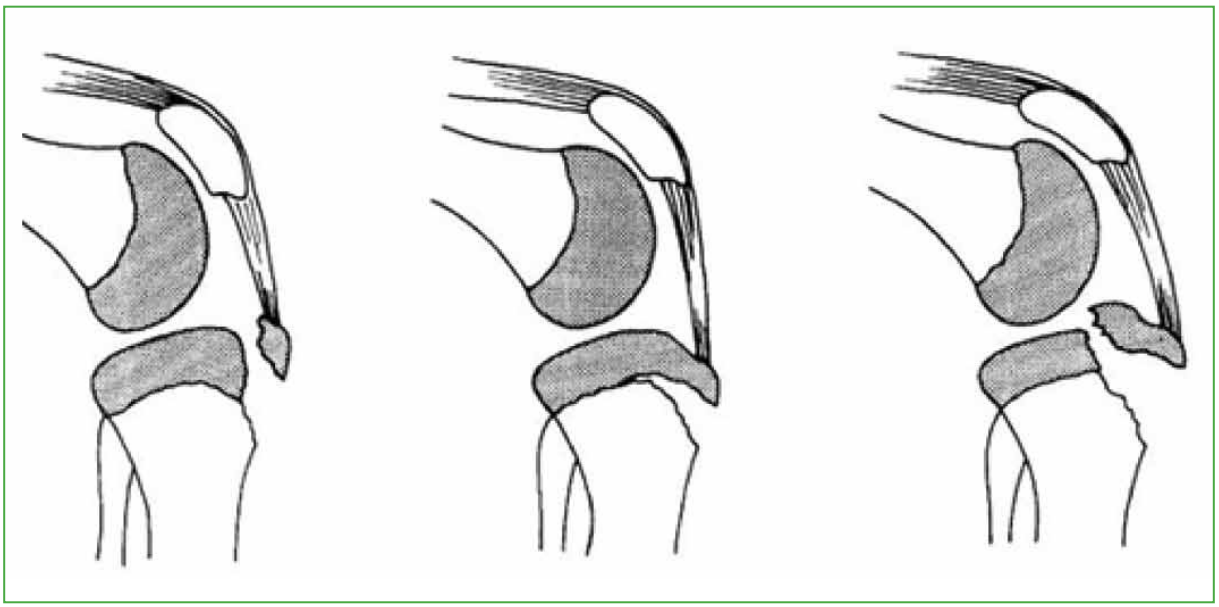

Figure 2. Watson-Jones classification for avulsion fractures of the anterior tuberosity of the tibia.

OBJECTIVE

The purpose of this article is to report the presentation, diagnosis, and treatment of a clinical case, compare it to similar published cases, analyze the differences, and draw a conclusion based on the experience gained in its resolution.

CLINICAL CASE

A 13-year-old male reported having suffered direct trauma to the right knee during running in sports practice (soccer) one month earlier. Physical examination found an antalgic gait that required crutches and a knee immobilizer, edema in the ATT region, patella alta, and pain on palpation and flexion-extension. AP and lateral radiographs (Figure 3) and a comparative radiograph of the contralateral limb revealed ATT avulsion, type IIIA of the Ogden classification. Computed tomography showed ATT avulsion with a fracture line extending to the articular surface of the tibia, with displacement.

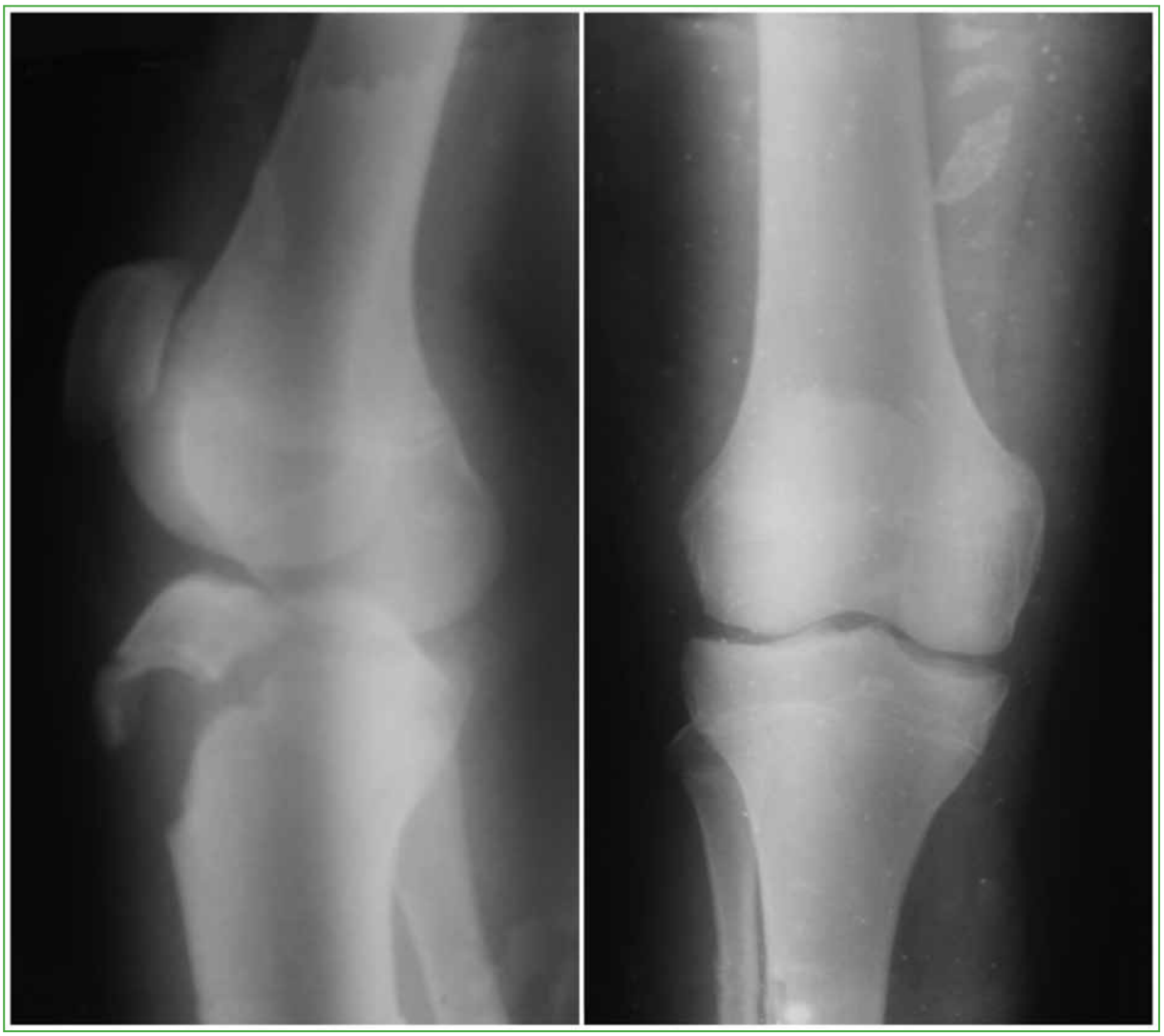

Figure 3. AP and lateral radiographs of the knee.

The surgery involved an open reduction and osteosynthesis, as well as the insertion of two parallel screws that did not impact the physis (one in the metaphysis region and the other in the epiphysis region). During the operation, a patellar tendon injury was discovered along with invagination of the distal fibers in the fracture site. The tendon was released and a suture was made at the level of the periosteum, in the anterior region of the proximal tibia (Figures 4 and 5). Reduction and osteosynthesis were performed with two 3.5-mm parallel screws and a washer in the epiphysis and metaphysis (Figures 6-8). A long leg cast was placed in extension without weight bearing for six weeks, after which rehabilitation treatment started. (Figure 9).

Three months after surgery, the patient walked and ran with full weight bearing; radiographs revealed no changes and no complications; and the arc of motion ranged from 0° to 120° of flexion-extension. Six months after surgery, the patient resumed his sports practice with a flexion-extension of 0° to 135°, which showed a good arc of motion, without pain or discomfort.

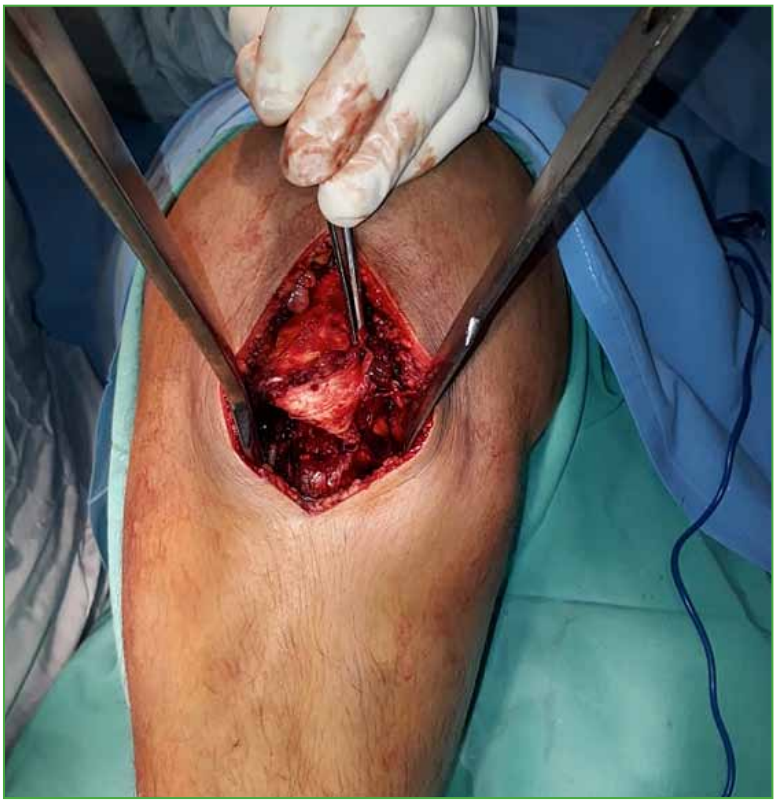

Figure 4. Approach over the anterior tuberosity of the tibia showing the patellar injury and avulsion.

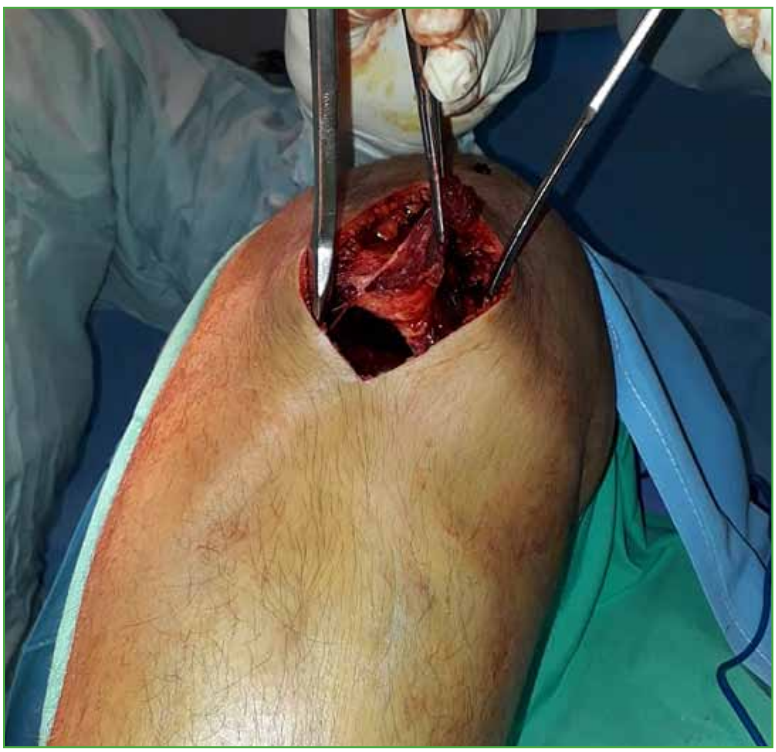

Figure 5. Fracture line of the anterior tibial tuberosity plus exploration of the invaginated tendon.

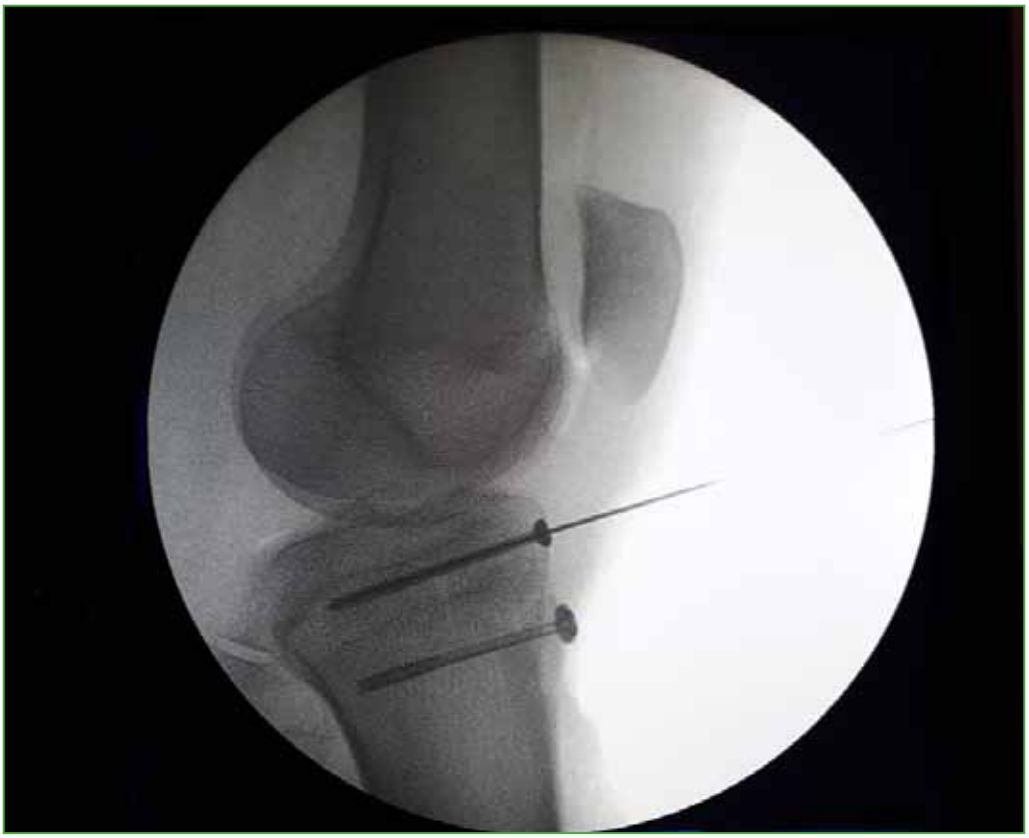

Figure 6. Lateral knee radiograph. Ostesynthesis with cannulated screws.

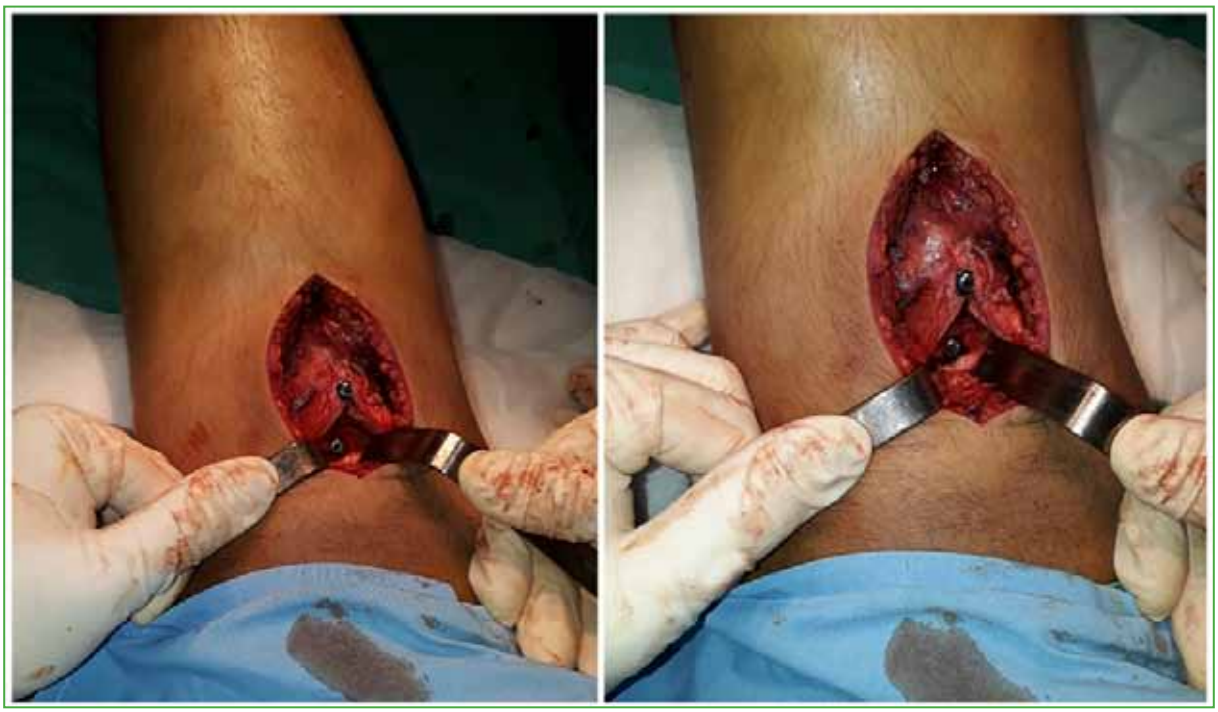

Figure 7. Placement of cannulated screws on the anterior tibial tuberosity.

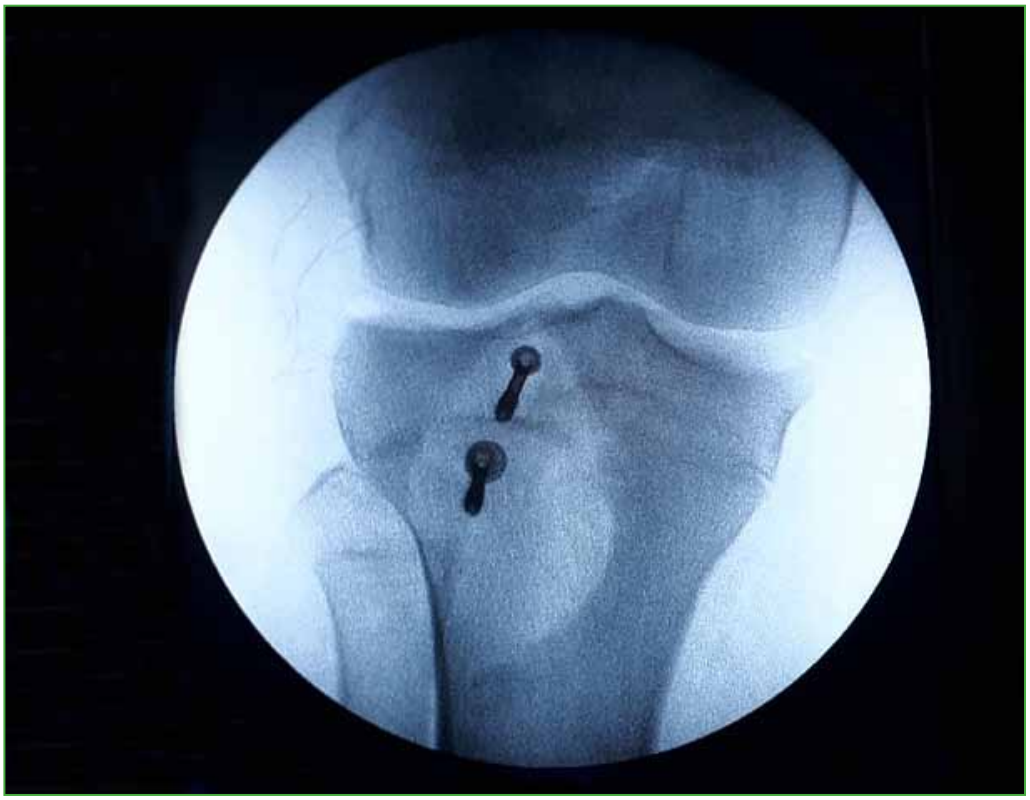

Figure 8. AP knee radiograph. The cannulated screws are visualized.

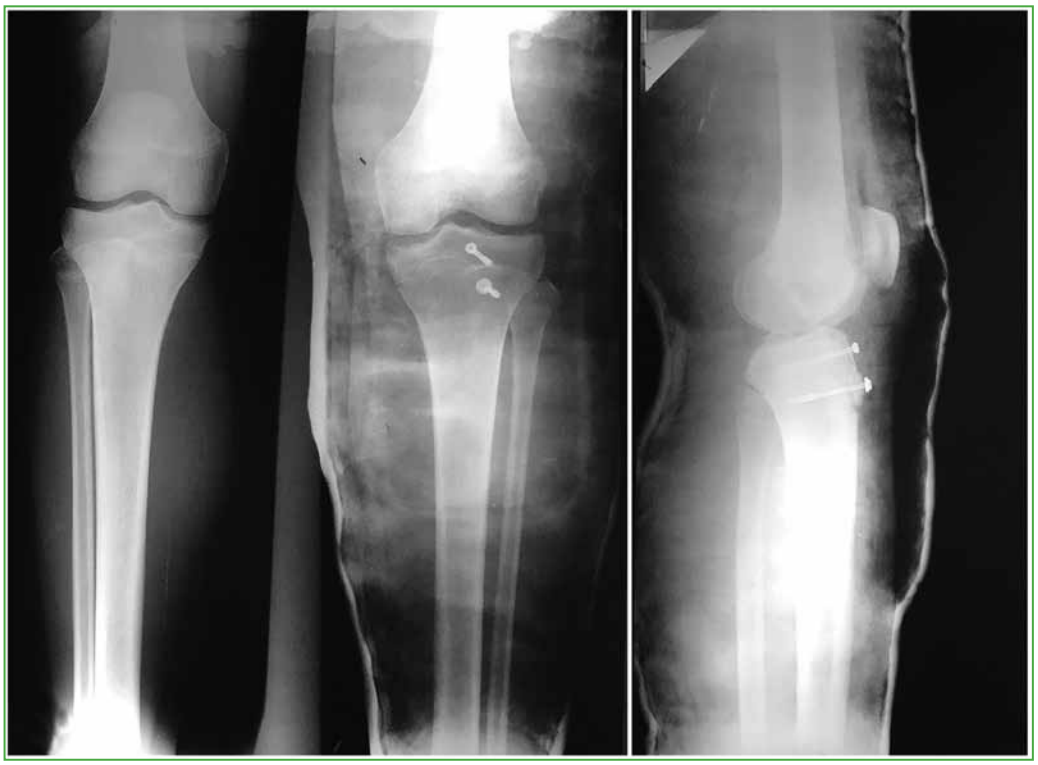

Figure 9. AP and lateral radiographs of the knee. The osteosynthesis material in the anterior tibial tuberosity and the immobilization with long leg cast are shown.

DISCUSSION

Different types of surgery have been proposed for injuries affecting the joint (Odgen type III). Agrelo et al. suggest that open reduction and internal fixation with two parallel screws is an adequate treatment that does not cause complications, after a six-month follow-up.[3] Pesl and Havranek recommend closed reduction and internal fixation using percutaneous cannulated screws as the first line of treatment for Ogden type III injuries; if the physis is still open, they suggest pinning (success rate >80%),[5] but not exploring the patellar tendon. Bauer et al. advise extreme caution with this type of injury and recommend looking for associated injuries. These authors use cerclage to protect the patellar ligament repair and avoid the use of washers for osteosynthesis.[6] Nikiforidis et al. also recommend cerclage, because fixation allows for earlier and easier rehabilitation, but requires a second surgical procedure to remove the material.[7] Medus and Maestu also opted for cerclage and immobilization until the third week, then progressed to partial weight bearing in the fourth week, reaching 90° of flexion in the eighth week, followed by cerclage removal and a new intervention in the twelfth week.[8]

Casas-Lopez et al. always recommend exploring the extensor mechanism and ruling out the interposition of soft tissues or other structures that may be involved in type II and III injuries. Additionally, they state that the use of pins or screws does not depend on the patient's age, but rather on the type of injury and the dimensions of the fragments, thereby avoiding displacements. Correct fixation and placement of the material will be crucial in case of potential growth in the proximal tibial physis.[9]

As other authors (Balmat et al.),[10] we use two partially-threaded cannulated screws plus a washer, placed in parallel, one in the epiphysis and the other in the metaphysis, avoiding the physis. Previously, we explore the fracture line for the interposition of the patellar tendon and, unlike Nikiforidis et al., we do not use cerclage. These authors use cerclage and implement early rehabilitation without immobilization and walking without weight-bearing, assisted with crutches until the sixth week, followed by cerclage removal in the eighth week, and require a second surgical procedure for the removal of the material, which delays the return to sport and may cause quadriceps atrophy. We also differ from Pesl and Havranek, who perform internal fixation with percutaneous screws as a first attempt without tendon exploration; in this case, the immobilization time, full weight bearing, and time until return to sports activity were shorter, as described by Agrelo et al. and Casas-López et al. In our case, it was not possible to perform an MRI as suggested by Tuca and Pineda[11] because we did not have a scanner and the patient did not have meniscus symptoms in the clinical controls.

This author conducted a 5-year follow-up, and found a fully recovered range of motion between week 4 and 8; the patients under evaluation returned to their activities at the third month, but all had quadriceps atrophy. Medus and Maestu also opted for cerclage and cast immobilization until week 3, then removed the cast and allowed partial weight bearing at week 4, reaching 90° of flexion at week 8, followed by cerclage removal and a new procedure at week 12.

CONCLUSIONS

Soccer is one of the most popular sports in Argentina, thus the low prevalence of these cases, both reported and observed in everyday practice, is noteworthy. However, it is possible that this is the main cause in our country. Other countries, where the main sport is basketball or athletics, which entail high and long jumping, account for the majority of cases. Although there is no consensus on the diagnosis and treatment due to the low number of published cases, increasing sports participation among young people increases the number of cases; thus, it is prudent to suspect this condition in young people who suffer a knee traumatism with extension limitation.

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Spinal Cord Contusion in Rats Treated with Systemic Hypothermia. Experimental Cold-inducible Protein Expression

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ABSTRACT

Introduction: Traumatic spinal cord injury is the leading cause of motor disability worldwide, and the WHO considers it a priority. This study sought to investigate the effects of therapeutic hypothermia following spinal cord contusion. **Materials and Methods:** Male rats that underwent experimental spinal cord contusion were used. For this purpose, four experimental groups were created (n=6 per group): a) control, b) lesion in normothermia (24°C, sacrificed 12h after the injury), c) lesion in normothermia (24°C, sacrificed 24h after the injury), and d) hypothermic injury (8°C for 180 min, sacrificed 24h after the injury). The expression of cold-inducible RNA-binding protein (CIRBP), Caspase-3, and NeuN was studied. **Results:** At 24 hours, spinal cord damage raised CIRBP expression slightly while also increasing Caspase-3 significantly. All of this was accompanied by images of damaged motor neurons in the anterior horn. In animals treated with hypothermia, high expression of CIRBP and very low levels of Caspase-3 were observed, which were indistinguishable from controls. Furthermore, the number of viable motor neurons was partially restored. **Conclusions:** The experimental model developed in this study was effective at inducing spinal cord injury, demonstrating neuronal protection through hypothermia. The increased expression of CIRBP in the spinal cord of rats with injury and hypothermic treatment when compared to the normothermic group suggests the possibility of using substances that increase CIRBP as therapies for the treatment of contusive spinal cord injuries.

Keywords: Contusion; hypothermia; spinal cord; CIRBP; rat; injury.

Level of Evidence: I

Contusión medular en ratas tratadas con hipotermia sistémica. Expresión de proteínas inducibles por frío experimental

RESUMEN

Introducción: La lesión traumática de la médula espinal es la principal causa mundial de discapacidad motora y una prioridad para la OMS. El objetivo de esta investigación fue estudiar el efecto de la hipotermia terapéutica tras una contusión medular. **Materiales y Métodos:** Se utilizaron ratas macho a las que se les generó una contusión medular. Se formaron cuatro grupos (6 animales por grupo): a) de control, b) con lesión en normotermia (24 °C, sacrificados 12 h después de la lesión, c) con lesión en normotermia (24 °C, sacrificados 24 h después de la lesión) y d) lesión en hipotermia (8 °C, durante 180 min, sacrificados 24 h después de la lesión). Se estudió la expresión de la CIRBP, la caspasa-3 y la Neu-N. **Resultados:** La lesión medular aumentó ligeramente la expresión de CIRBP a las 24 h y, de manera importante, la de caspasa-3, todo acompañado por imágenes de motoneuronas dañadas en el asta anterior. En los animales tratados con hipotermia, se observó una alta expresión de CIRBP y niveles muy bajos de caspasa-3, que no se distinguen de los controles. El número de motoneuronas viables se restauró parcial-

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mente. **Conclusiones:** Este modelo experimental resultó eficaz para inducir una lesión medular, demostró la protección neuronal mediada por hipotermia. El aumento de la expresión de CIRBP en la médula espinal de ratas con lesión e hipotermia comparado con el del grupo normotérmico abre el camino para un posible uso de sustancias que incrementen la CIRBP como terapéutica para las lesiones medulares contusivas.
Palabras clave: Contusión; hipotermia; médula espinal; CIRBP; rata; lesión.
Nivel de Evidencia: I

INTRODUCTION

Every year, around 500,000 people worldwide suffer spinal cord injuries, increasing their likelihood of dying prematurely.[1] According to the National Rehabilitation Service of Argentina, in 2013, 2,176,123 patients with disabilities were identified (54% males and 46% females), of whom 30% suffered from a pure motor disability.[2] This creates the need to seek new therapies to improve the quality of life of patients. Our proposal is to investigate the therapeutic use of hypothermia. In our laboratory, we have shown that it can minimize central nervous system damage in mouse models of perinatal asphyxia and optic nerve trauma, with encouraging outcomes.[3-13] A slight reduction in body temperature protects the central nervous system against various types of damage.[3,5,8,12-14]

Numerous publications show that mild levels of hypothermia after injury improve neurological function and reduce histopathological damage in the bone marrow.[14-18] The neuroprotective role of hypothermia is well established in experimental animals and in patients with cardiac arrest (Hakim et al., 2018), hypoxic-ischemic encephalopathy (Yum et al., 2018), traumatic brain injury (Leng, 2017), and other diseases (Zhu et al., 2015). Although the neuroprotective mechanisms of hypothermia in different diseases vary and have not yet been fully determined, neuroprotection has been commonly attributed to its effect on decreasing metabolic rate, reducing radical generation, improving inflammation, inhibiting excitotoxicity and apoptosis. Increased expression of different cold-inducible proteins such as CIRBP (cold-inducible RNA binding protein) and RBM3 (RNA binding motif protein 3) has been described. CIRBP, also known as CIRP or heterogeneous ribonucleoprotein A18 (hnRNP A18), is an 18 kDa protein composed of 172 amino acids whose gene in humans is located on chromosome region 19p13.3. Like other members of the hnRNP family, CIRBP binds to messenger and ribosomal RNA present in the cell and regulates its half-life, the potential expression of multiple genes and thus its function. As with other RNA-binding proteins, CIRBP has been shown to be able to modulate apoptosis by playing an anti-apoptotic role in hypothermia situations. In rat neuronal cells, this effect appears to occur through the mitochondrial apoptosis pathway, as they show decreased expression of proapoptotic molecules (Bax, Bad, Bak, Cycs, Apaf1, caspase-9 and caspase-3). Recently, we have shown increased expression of CIRBP in the anterior horn the spinal cord of rats subjected to systemic hypothermia.[7,9,11,12,19-24] Taking this background into account, the objective of this study was to evaluate the effects of cold on spinal cord protection by expressing CIRBP in motor neurons of the anterior horn of the spinal cord of rats exposed to spinal cord injury and treated with systemic hypothermia. To do this, we applied our hypothermic model as a treatment for spinal contusion (MASCIS®),[25] and studied the expression of CIRBP as a protein induced by hypothermic treatment, and that of caspase-3 and NeuN to study neuron viability.

MATERIALS AND METHODS

Model and experimental design

The procedures were conducted according to the National Institutes of Health Guidelines for the Care and Use of Laboratory Animals (CCAC 2002; CCAC 2003). The protocol was approved by CICUAL, resolution No. 970/2015 (Universidad de Buenos Aires, Argentina). The Sprague Dawley rat (developed from Winstar) is an exogamous, multipurpose breed of albino rat widely used in medical research. Its advantages include its docility, ease of use, and our laboratory experience with this breed, which we have been working with in hypothermia since the 1980s.

Twenty-four 60-day-old adult male Spargue-Dawley rats were used and distributed into four groups (6 per group): a) control, b) with 12 h NT injury: injury in normothermia at 24 °C and euthanized 12 h after injury, c) with 24 h NT injury: injury in normothermia at 24 °C and euthanized 24 h after injury, and d) with 24 h HT injury: injury in hypothermia at 8 °C, in a cold room, for 180 min and euthanized 24 h after injury.[24] Animals were administered intraperitoneal anesthesia with a mixture of xylazine (Rompun®, Bayer, Kiel, Germany) 10 mg/kg body weight and ketamine (Ketolar®, Pfizer, Alcobendas, Madrid, Spain) 60 mg/kg body weight. The animal was placed on the surgical platform with a bolster under the thorax to help separate the spinous processes and a warm IV bag at 38 °C was used as a bed to prevent hypothermia throughout the procedure. The thoracic spinal cord was surgically exposed through a dorsal incision and laminectomy from T9 to T11. The spinal contusion was caused with the MASCIS® impactor, according to published protocols. Briefly, it entails dropping a 10 g bar that is elevated to 25 mm high, resulting in a 24 g damage load when it directly impacts the dorsal area of the rat spinal cord in T9-T10.[25] After the contusion, the wound was surgically closed and the animals were placed in individual boxes for recovery under standard vivarium conditions at 24 °C (groups with 12 h NT injury and 24 h NT injury), or exposed to hypothermia at 8 °C, in a cold room, for 180 min, after the injury and then transferred for recovery under standard vivarium conditions at 24 °C (group with 24 h HT injury). Hypothermia control was performed as detailed in previous studies of the research group.[7-13] The vivarium has light/dark cycles of 12/12 hours. Tylenol® was used for postoperative analgesia (65 mg/kg). Euthanasia was by decapitation 12 or 24 h after the injury as indicated above. Tissue processing was performed following the procedure described in previous publications.[12,26]

Hematoxylin & eosin

Spinal cords from the injured thoracic region were immersed in paraffin, cut into 5 µm thick coronal sections with a microtome (Leitz, Lauda MGW, Germany), and placed on gelatin-coated slides. Spinal cord slices were hydrated with xylene, followed by decreasing alcohol concentrations, and finally stained with hematoxylin-eosin. The stained sections were observed with an optical microscope (Carl Zeiss Axiophot, Germany) connected to a digital camera (Olympus, Q-Color 5, USA) and photographed for analysis using the NIH Image program (Wayne Rasband, 1995, NIH, Research Services Branch, NIMH, Bethesda, MD, USA).

Immunohistochemistry

Spinal cord sections were rehydrated, endogenous peroxidase was inhibited with H_2O_2 (3% in methanol) and nonspecific binding was blocked with incubation in normal goat serum. Sections were then incubated in a wet room overnight at 4°C with rabbit polyclonal anti-CIRBP primary antibodies (Proteintech®, UK, Cod. 00055668) in a 1:1000 dilution or mouse monoclonal anti-NeuN antobodies (Abcam, Cod. ab177487) in a 1:1000 dilution. The anti-NeuN antibody recognizes a molecule with a molecular mass of 46/48 kDa known as neuron specific nuclear protein (NeuN or "NEUronal Nuclei"), which is located in the DNA-binding domain of most viable neurons in the central nervous system, and thus was used in this study to quantify neuronal viability. The next day, immunoreactivity was developed with species-specific biotinylated secondary antibodies: anti-rabbit (Vector Labs, USA, catalog number PK-6101) or anti-mouse (Abcam Labs, USA ab6788) as appropriate, both at 1:200 dilution. Labeling was detected by diaminobenzidine, using the commercial kit SK-4100 (Vector Laboratories, USA). The analysis of the degree of response and the number of immunoreactive cells was performed with an optical microscope (BX40, Olympus Optical Corporation, Tokyo, Japan), coupled to a digital camera (390CU 3.2 Megapixel CCD Camera, Micrometrics, Spain), using the program Micrometrics SE P4 (Standard Edition Premium 4, Micrometrics, Spain). Three animals per experimental group were analyzed.[27]

Tissue processing for Western blot

The membrane was incubated with rabbit anti-CIRBP antibody (Proteintech®, UK) at a 1:1000 dilution and mouse monoclonal anti-CIRBP-3 antibody at a 1:500 dilution (Santa Cruz Biotech. A2921, USA). The membrane was then incubated with rabbit anti-IgG antibody (Amersham Pharmacia Biotech, USA) at a 1:5000 dilu-

tion or mouse anti-IgG at a 1:3000 dilution (Amersham Pharmacia Biotech, USA) as appropriate. The ECLTM detection kit (Amersham™) was used for development. The bands were visualized with the UVP Biospectrum/Biolite imaging system (Analytik Jena). Three animals per experimental group were analyzed. As a loading control, the membrane was incubated with mouse anti-ß-actin monoclonal antibody (Sigma-Aldrich, St. Louis, MO, USA) in a 1:5000 dilution. The molecular weight of the protein bands was estimated using a commercial protein ladder (PageRuler®, Fermentas UAB, Vilnius, Lithuania).

Image analysis

Images of sections with hematoxylin-eosin staining or immunostaining were obtained by microscopy and digitized. The quantification of immunopositive neurons was performed as previously published by our research group. [3,7-13] Spinal cord sections were selected to be comparable between animals. The relative optical density of immunopositive neurons and the number of immunoreactive neurons were determined with ScionImage image analysis software. In anti-NeuN staining, viable motor neurons were those with a homogeneous label in the nucleus and cytoplasm. Six sections per antibody were analyzed and 10 fields per section were counted using 40X magnification. A label was considered immunopositive when its optical density exceeded 4 times or more the optical density of the background. For the quantification of the optical density of the bands obtained by Western blot, ImageJ software (NIH, USA) was used. The CIRBP and caspase-3 optical density values obtained in the Western blots were normalized according to the corresponding ß-actin optical density value and the results were expressed as mean value of the group ± standard deviation and as a percentage in relation to the control group. All experiments were performed in duplicate.

Statistical Analysis

The data obtained was loaded into a database that was analyzed with the statistical package InfoStat version 2020 and graphed using the GraphPad Prism program (version 5.0 for Windows, GraphPad Software). To determine if the differences observed between the groups were statistically significant, a one-way analysis of variance (ANOVA) was performed followed by Tukey's test. Before testing the hypothesis, the assumptions of normality were verified using the modified Shapiro-Wilk test and the assumptions of homogeneity of variances were verified using the Lavene test. A difference $p < 0.05$ was considered statistically significant.

RESULTS

Western blot

A band of ≈20.5 kDa was obtained indicating CIRBP expression, 37 kDa for caspase-3 and 42 kDa for actin (Figure 1A). For CIRBP, a significant increase in expression can be observed in the 24 h HT injury group compared to the control and 12 h NT injury group (Figure 1B). In terms of caspase-3 expression, a significant increase is observed in the 12 h and 24 h NT injury groups compared to the control group. It should be noted that rats treated with hypothermia (24 h HT injury) had a significant decrease in caspase-3 levels compared to both groups injured in normothermia, becoming indistinguishable from the control group (Figure 1C).

Morphology

We obtained images of the anterior horn of the spinal cord corresponding to Rexed laminae VII, VIII, and IX, and we analyzed the alpha motor neurons using hematoxylin-eosin histology and immunohistochemistry for CIRBP and NeuN.

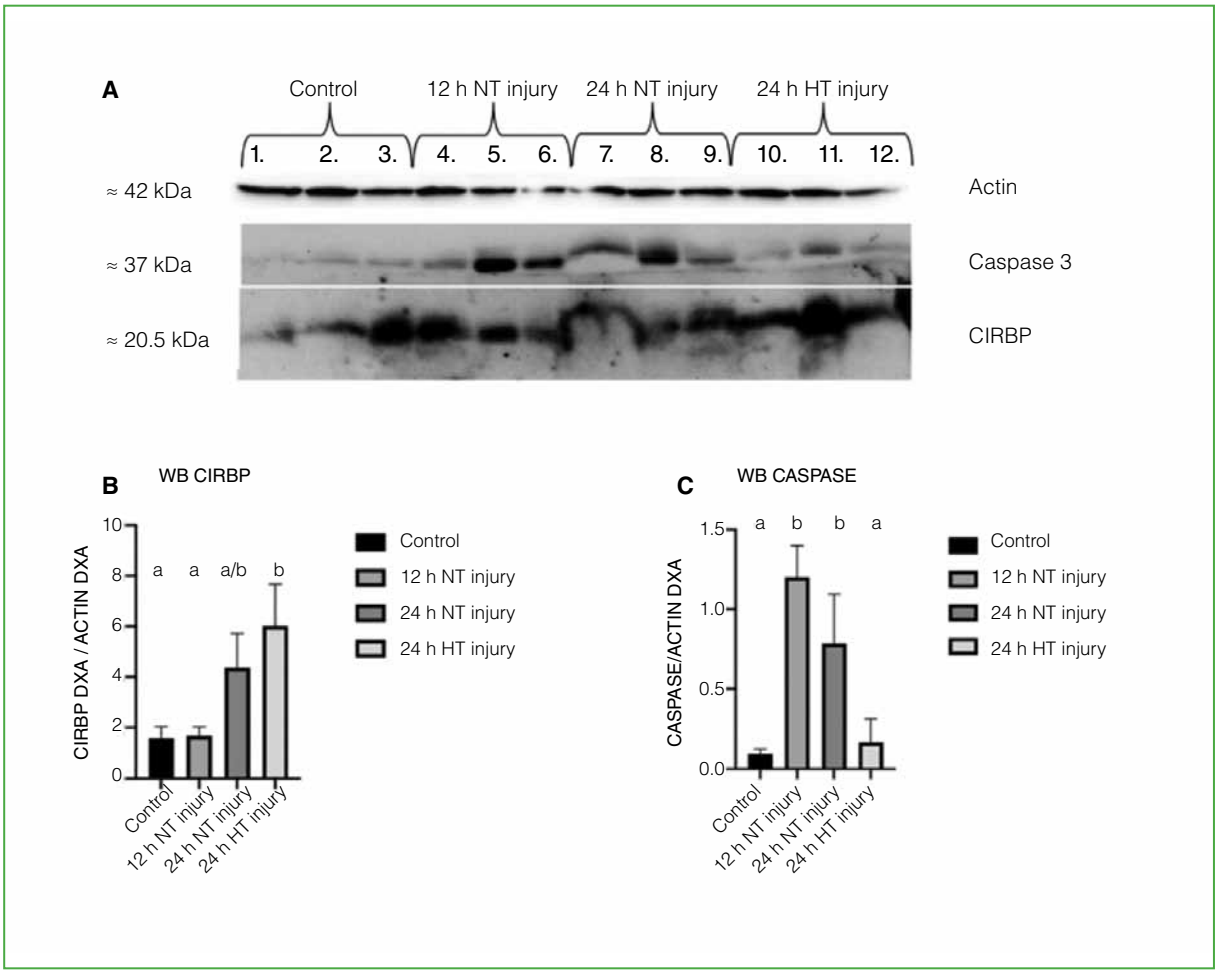

Figure 1. A. Western blot of spinal cord homogenates from all 4 groups, immunostaining for CIRBP, caspase-3 and actin loading control. **B.** Semi-quantification plot of CIRBP bands by densitometry and analysis, ANOVA test and Tukey's test. A significant difference is observed between the 24 h HT lesion group and the control group (a/b $p < 0.05$). **C.** Semi-quantification plot of caspase-3 bands by densitometry and analysis, ANOVA test and Tukey's test. A significant difference is observed between the 12 h NT and the 24 h NT injury groups, and the control and 24 h HT injury groups ($p < 0.05$).
NT = normothermia; HT = hypothermia.

Hematoxylin & eosin

In the controls, the structure remains unaltered, with an H-shaped distribution of gray matter and visible large motor neurons. In the slices of the other experimental groups, there is a loss of cohesion, as evidenced by an area of early degeneration and the disappearance of the neurological structure, giving place to a lesional cavitation caused by spinal cord injury with some blood elements. (Figure 2).

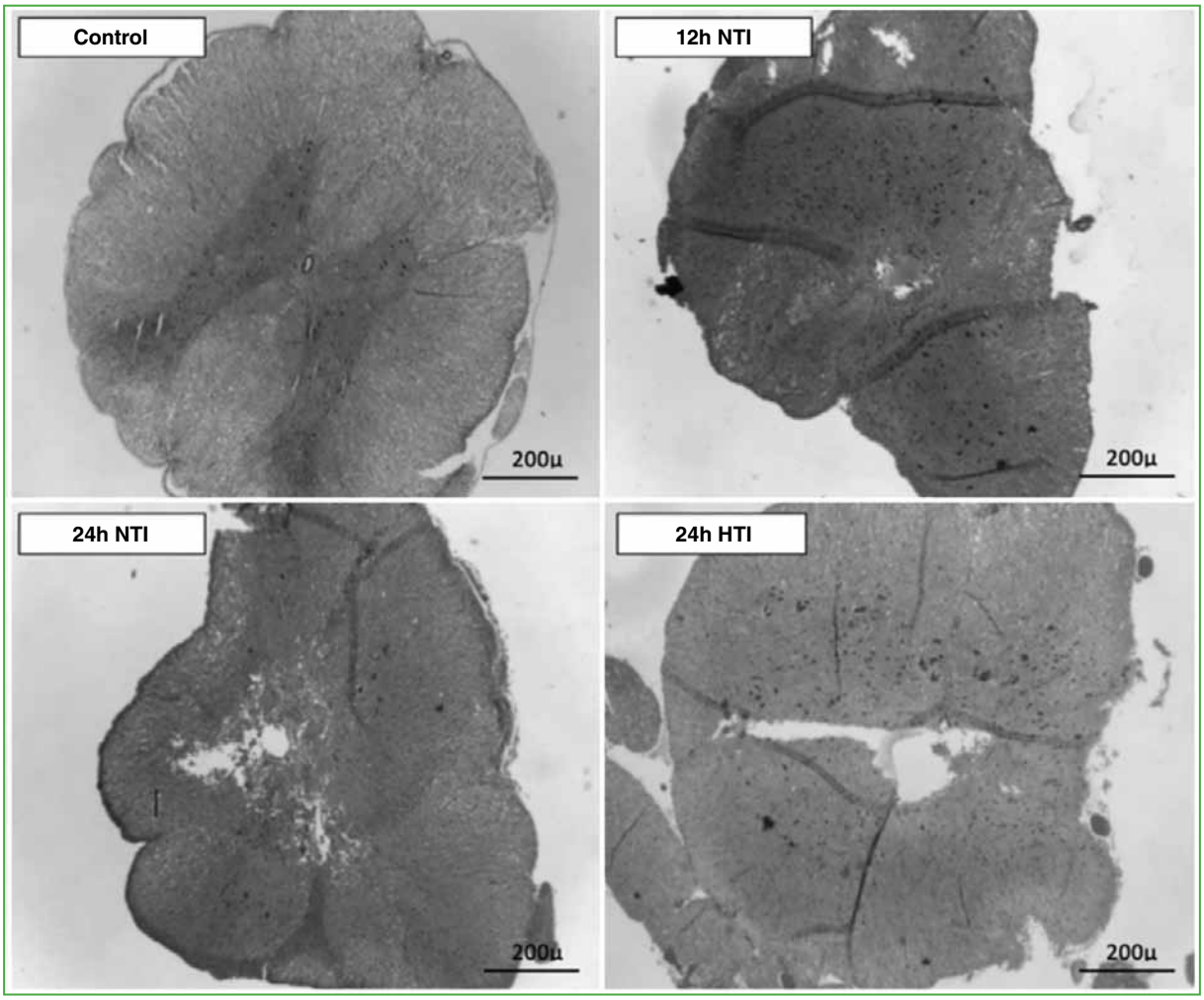

Figure 2. Spinal cord sections stained with hematoxylin & eosin. x10 magnification. Cohesion loss is marked by an area where early degeneration occurs and the usual neurological structure disappears, giving way to post-injury cavitation with some blood elements.
NT = normothermia; HT = hypothermia.

Immunohistochemistry

CIRBP Expression

In the control group, CIRBP shows a weak immunoreactive label with cytoplasmic distribution and its expression is slightly higher in the nucleus and neuropil. In the images of 12 and 24 h NT injured rats, the label was somewhat higher than that of the control group. The group with 24 h HT injury exhibited intense labeling in the nucleus and in the form of cytoplasmic "granules", in the alpha motor neurons and the surrounding neuropil (Figure 3).

When quantifying the optical density for CIRBP, a significant increase in the optical density of CIRBP was observed in the 24 h HT injury group compared to the control group ($p = 0.01$), without differences when compared to the rest of the experimental groups (Figure 4, Table 1).

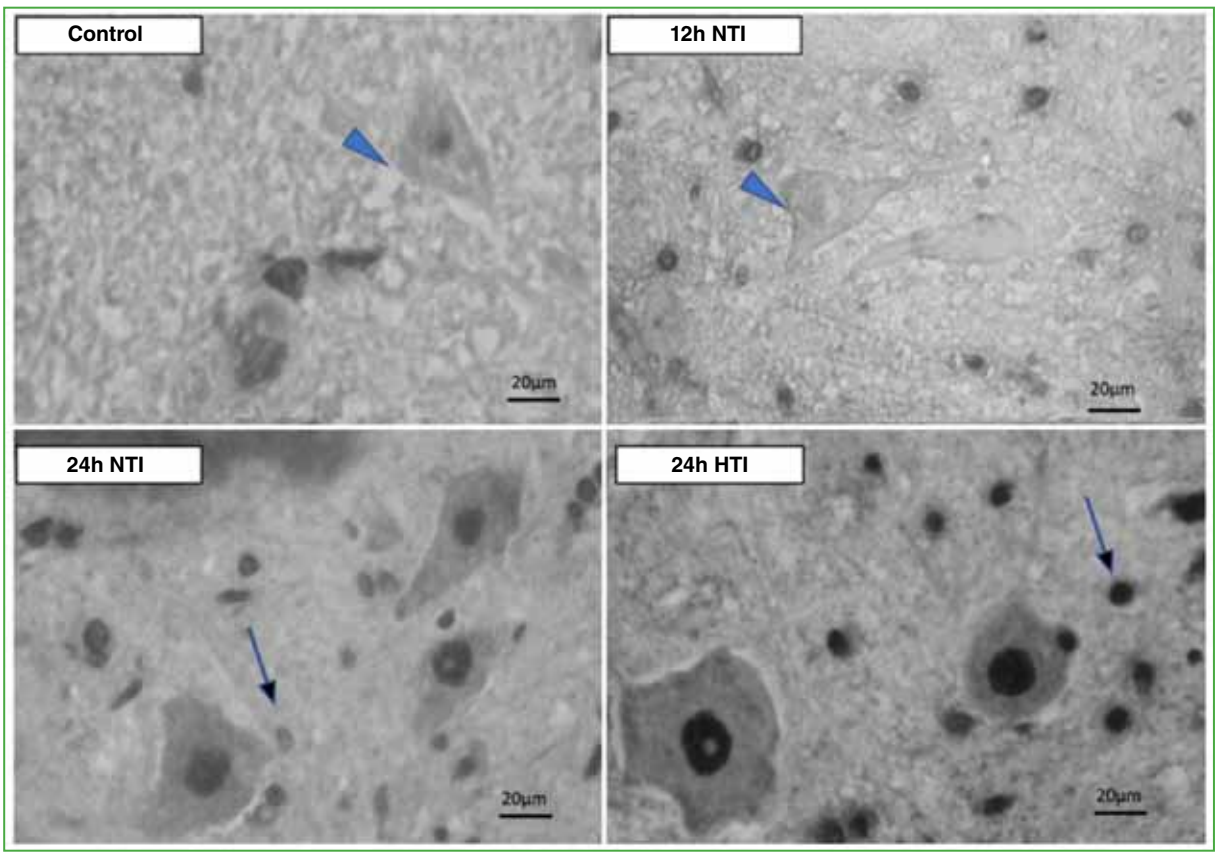

Figure 3. CIRBP. Comparative slices. x40 magnification. Magnification of Rexed laminae VII and VIII. Motor neuron with weak labeling in the controls and within 12 h of the injury (arrowhead). The label increases after 24 h in normothermia with an expression greater than 24 h with hypothermia. Glial cells with higher concentration in injured groups (arrows).
NT = normothermia; HT = hypothermia.

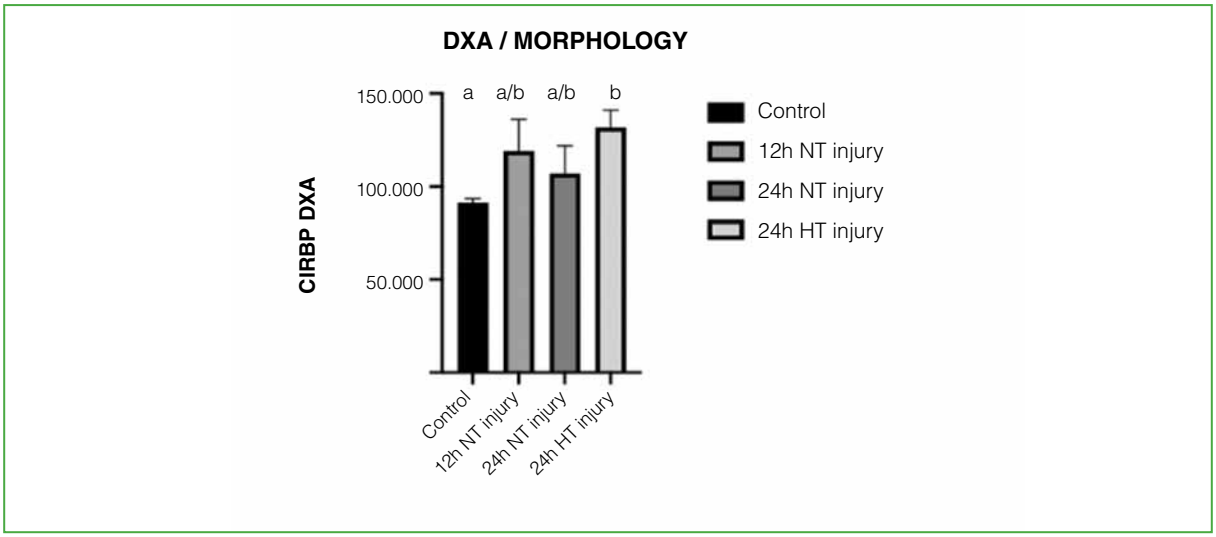

Figure 4. Densitometric quantification plot of immunohistochemistry with anti-CIRBP antibodies in spinal cord sections of three rats per group: control, with 12 h and 24 h NT injury, and with 24 h HT injury. As observed in previous micrographs, there is a progressive increase in CIRBP expression, which is lower in control animals, moderate between 12 h NT and 24 h NT, and significant with 24 h HT. The analysis with the ANOVA test and the Tukey test revealed a significant difference between the control group and the group with 24 h HT injury (a/b $p<0.001$). NT = normothermia; HT = hypothermia.

Table 1. Relative optical density (ROD) of CIRBP in immunohistochemistry.

Groups	Average difference	95% confidence interval	Significant	p
Control vs. Normothermia 12 h	-27785	From -59942 to 4372	No	0.0924
Control vs. Normothermia 24 h	-15734	From -47892 to 16423	No	0.4462
Control vs. Hypothermia 24 h	-40419	From -72577 to 8262	Yes	0.0161
Normothermia 12 h vs. Normothermia 24 h	12051	From -20107 to 44208	No	0.6436
Normothermia 12 h vs. Hypothermia 24 h	-12634	From -44792 to 19523	No	0.6110
Normothermia 24 h vs. Hypothermia 24 h	-24685	From -56842 to 7472	No	0.1424

In the Tukey test, the significant difference between the control group and the 24 h HT group is observed; although the increase in CIRBP is observed in the NT injury groups, the difference is not significant between them as well as with the controls.

Cell viability by NeuN expression

Qualitatively, when assessing the immunohistochemical distribution of NeuN in the groups with NT injury, there is a decrease in the intensity of nuclear staining, with a perinuclear halo and eccentric nucleus, cytoplasmic retraction with irregular membrane. Some cells look like "ghost neurons", and the increase in glial cells is seen (Figure 5).

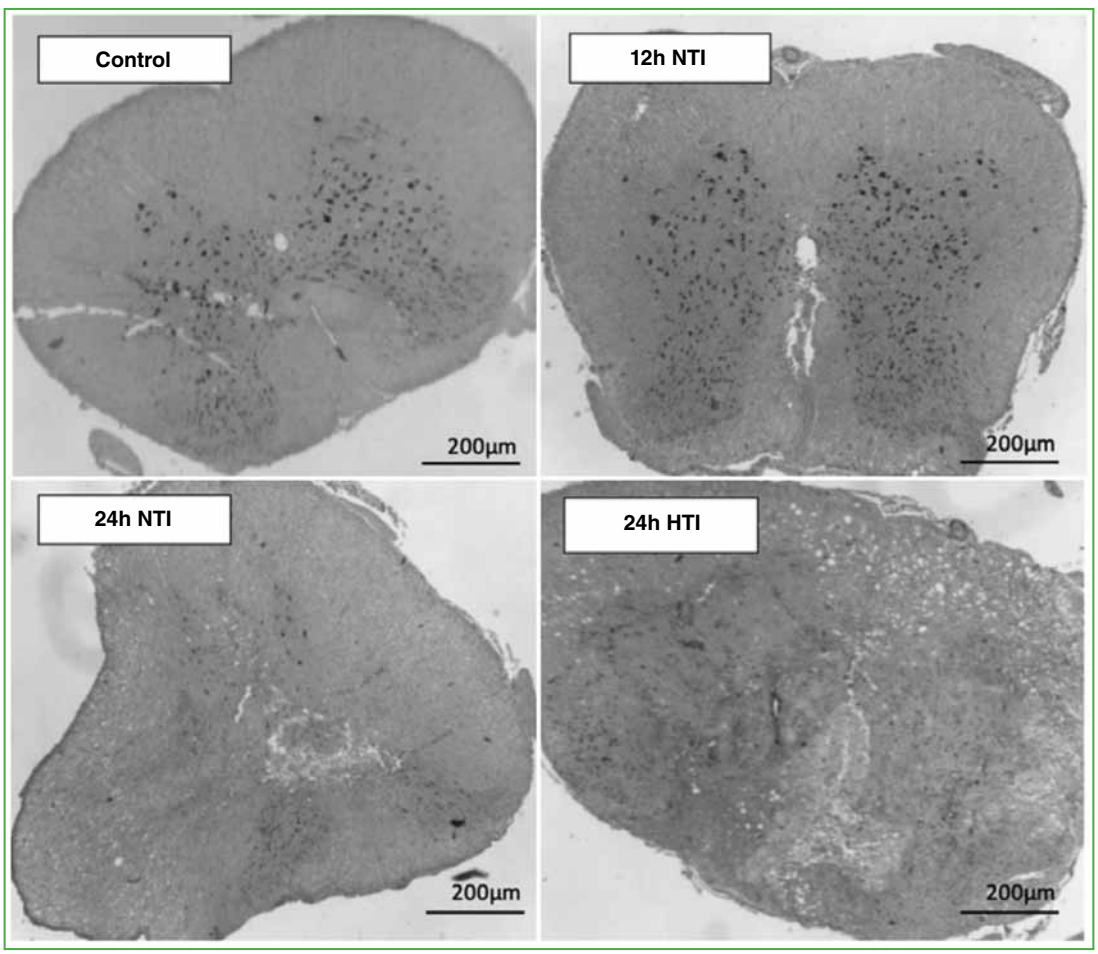

Figure 5. NeuN. Comparative slices. Magnification x4. Marked staining can be observed in both the control and the 12 h NT injury groups, as well as the 24 h HT injury group.

However, in the group with 24 h HT injury, neurons in the process of death were observed, but in fewer numbers (Figure 6).

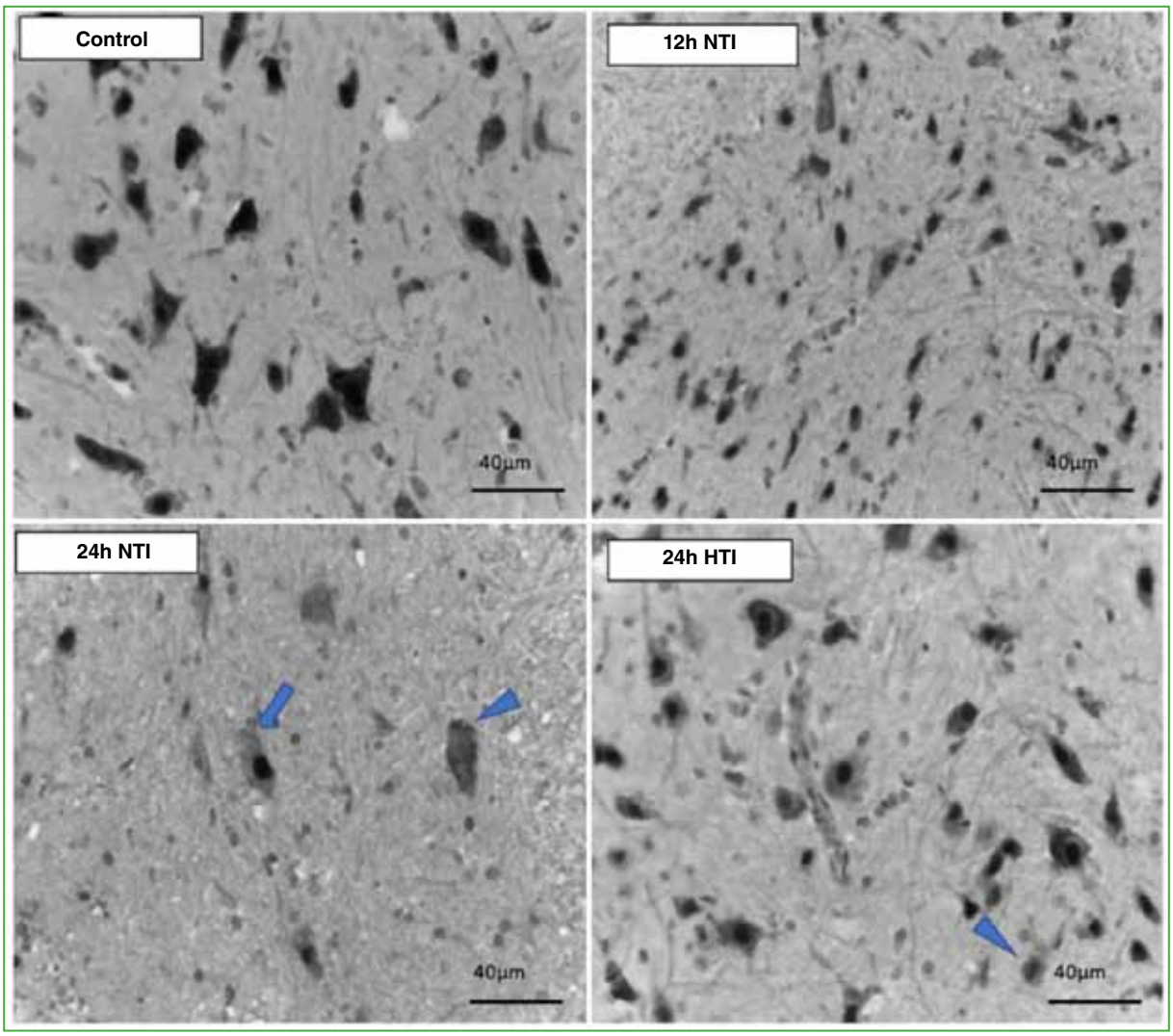

Figure 6. NeuN. Comparative slices. Magnification x2. Controls with strong label and surrounding glia without label for NeuN. The 12 h NT slices show a slight increase in glia and loss of staining in some neurons, something much more marked in the 24 h NT group, with ghost neurons (arrowhead) or neurons with eccentric nuclei (arrow). The 24 h HT injury looks similar to that of the 12 h NT group, with some motor neurons dying and mild staining loss (arrowhead).

When counting the number of viable neurons per field in spinal cord sections stained with NeuN immunolabeling, which marks the nerve fiber of vital cytoplasms and nuclei and is lost when the cell is dead or dying, cells with a central nucleus and homogeneous cytoplasmic staining were counted. A significant reduction was observed in the 12 h and 24 h NT injury groups compared to the control group ($p < 0.0001$) (Figure 7, Table 2).

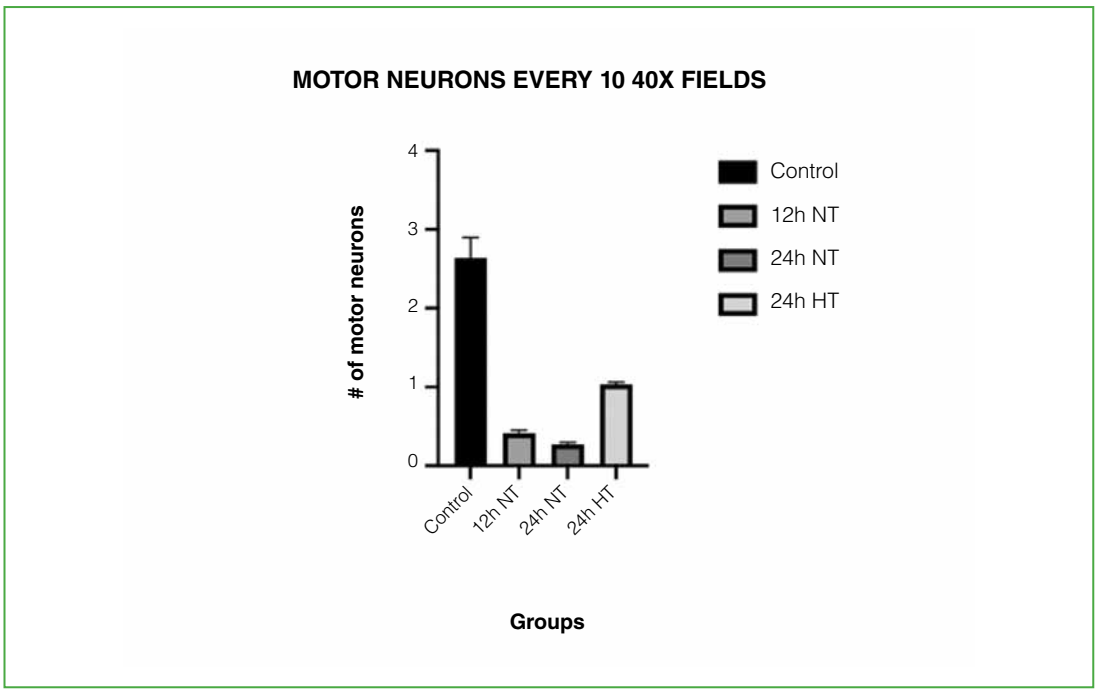

Figure 7. Densitometric quantification plot of immunohistochemistry with anti-NeuN antibodies in spinal cord sections of three rats per group: control, 12 h and 24 h NT, and 24 h HT. As observed in the previous micrographs, there is a loss of expression with progressive neuronal destruction between 12 h and 24 h of the NT injury group. In the group with 24 h HT injury, a persistence of viable motor neuron structure is observed. The analysis using the ANOVA test with the Tukey test revealed a significant difference between the control group and the group with 24 h HT injury (a/b $p<0.001$).

Table 2. Tukey multiple comparison test. NeuN immunohistochemistry

Groups	Average difference	95% confidence interval	Significant	p
Control vs. Normothermia 12 h	9.947	From 6.355 to 13.54	Yes	<0.0001
Control vs. Normothermia 24 h	10.54	From 6.946 to 14.13	Yes	<0.0001
Control vs. Hypothermia 24 h	6.227	From 2.635 to 9.819	Yes	0.0024
Normothermia 12 h vs. Normothermia 24 h	0.5917	From -3.000 to 4.184	No	0.95
Normothermia 12 h vs. Hypothermia 24 h	-3.72	From -7.312 to -0.1279	Yes	0.0426
Normothermia 24 h vs. Hypothermia 24 h	-4.312	From -7.904 to -0.7195	Yes	0.0206

Tukey multiple comparison test. Cell count under x40 magnification every 10 viable cell fields with anti-NeuN antibodies in the anterior horn of the spinal cord. There is a significant difference between groups, except between groups with 12 h and 24 h NT injury.

We also found a significant increase in the number of viable neurons in the 24 h HT injury group compared to both NT injury groups ($p < 0.002$). However, neuron levels in hypothermia did not reach control group levels (Figures 6 and 8).

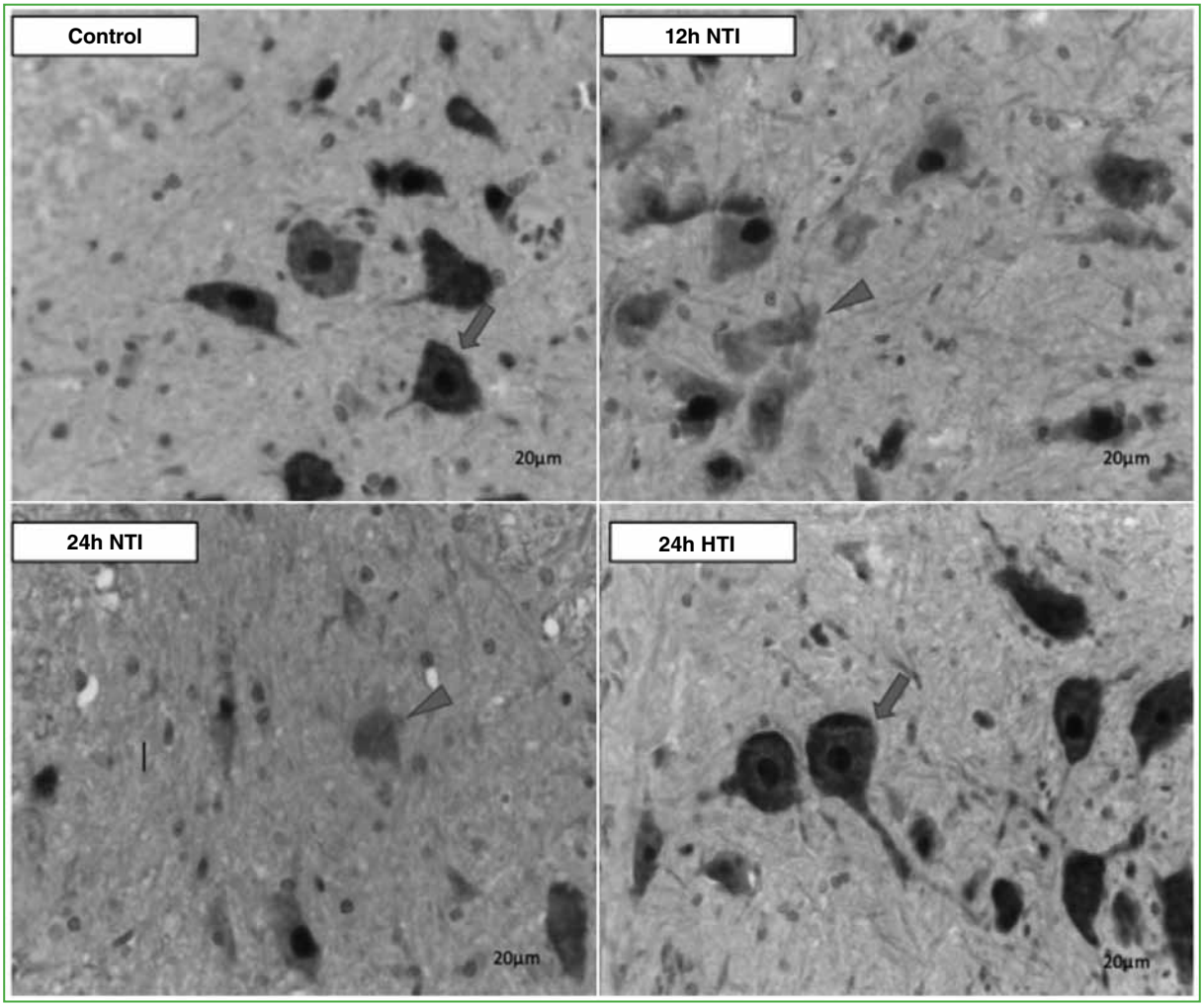

Figure 8. NeuN. Comparative slices. x40 magnification. NeuN staining with marked nuclear intensity can be observed in the control and 24 h HT injury groups, as well as moderate staining in the cytoplasm of motor neurons (arrows). Whereas, in the groups with 12 h and 24 h NT injury, neurons in the process of death are visualized (arrowhead).

DISCUSSION

Animal models of spinal cord injury are currently being developed to ensure that they are reliable, consistent, and that they reproduce the injuries seen in humans.[28,29] Questions remain as to their validity and whether they are comparable with clinical conditions in humans, which highlights the limitations of the article, particularly as only anterior horn motor neurons were evaluated. Some reviews have examined spinal cord injury models and their potential uses in mimicking this picture.[30,31]

Possible cold therapies to prevent neuronal damage after spinal cord injury are of two types: local and systemic. Local therapy has been used in the prophylaxis of spinal cord ischemia during aortic surgery. In this case, hypothermia by epidural cooling provides cytoprotection;[32] however, due to the complexity of the procedure, systemic

hypothermia is chosen.[33] Its risks include increased infection rates, renal insufficiency, necrosis of exposed areas, and scabies, so its management should be cautious. Evidence suggests using the latter when there is an acute spinal cord injury.[34]

CIRBP is considered a cytoprotective protein that accelerates cell recovery from stress.[35,36] Zhang et al. stated that it is a telomerase modulator at both 32 °C and 37 °C. CIRBP associates with the active telomerase complex through direct binding of the telomerase RNA component (TERC) and regulates the localization of telomerase in Cajal bodies.[37,38] The possible interaction of these bodies with small nuclear ribonucleoproteins could have implications for protection phenomena generated at the nuclear level. In 2019, Mingyue Liu (https://doi.org/10.1016/j.jtcvs.2018.08.100) described neuroprotective effects by reducing blood-brain barrier degradation in rats. In addition, Li-hui Chen published a study on hypothermia in 2013 (https://doi.org/10.21203/rs.3.rs-2628773/v1) and observed that overexpression of CIRBP in neurons could reduce OGD/R-induced (oxygen-glucose deprivation and reoxygenation) release of oxygen-reactive substances by reducing malondialdehyde levels and increasing superoxide dismutase and glutathione levels, reducing OGD/R-induced neuronal apoptosis by downregulating caspase-3 expression and upregulating Bcl-2 expression (known effects of CIRBP).

At the experimental level, systemic hypothermia has neuroprotective properties in cerebral and spinal cord ischemia.[39-41] Trials to perform it in experimental models generate great difficulties due to the costs and complexity of the systems.[42,43] Most have two drawbacks: invasiveness and costs.

In previous research, we have determined that brief exposure to cold induces the expression of CIRBP in the spinal cord of rats at the thoracic level (T8-T9-T10), its expression is significantly higher in animals exposed to hypothermia with different expression kinetics and time location post-intervention.[12] Based on this model, we move to a new stage where we evaluate the spinal cord injury and its cold treatment, measuring the expression of CIRBP and the number of viable neurons after injury.

The use of the MASCIS® impactor is proven to generate spinal cord contusion injury and is useful for various types of study, for example, that published by Colón et al., in 2017,[44] with the use of tamoxifen as post-injury treatment. In this study, rats were given a thoracic contusion (T10) using the impactor, and given placebo or tamoxifen granules (15 mg, for 21 days) at intervals of 0, 6, 12 and 24 hours. Euthanasia was performed 2, 7, 14, 28 or 35 days after injury to study molecular and cellular changes in acute and chronic stages. Immediate or deferred therapy (6 hours after injury) improved locomotor function and increased white matter tissue integrity and neuronal survival.[44] Although our study was not focused on chronic stages, the immediate outcomes (24 hours) of administering cold after moderate contusion were encouraging.

Research on the pathophysiological mechanisms of spinal cord injury has led to a classification scheme of primary and secondary injury.[45,46] The secondary type is divided into acute phase (0 to 48 h), subacute phase (2 weeks) and chronic phase (following the subacute phase and it can last years).[47] It is important to highlight and remember the authors that have made this difference, since the post-traumatic therapeutic action must be based on the treatment of secondary injury mediated by the inflammatory cascade, cytokines, proapoptotic proteins, as well as the causes associated with the relative hypoxia generated by multiple factors, such as the reduction of systemic blood pressure due to shock (may be due to pain, or neurogenic, or hypovolemic, or a combination of all), hypoxemia due to reduction of ventilation generated by states of coma or due to the reduction in excursion of the thoracic cage in inspiration and expiration due to pain.[48]

The caspase family regulates the execution of mammalian apoptosis. Caspase-3 cleaves several essential downstream substrates involved in the expression of the apoptotic phenotype *in vitro* (gelsolin, PAK2, fodrin, nuclear lamins and the inhibitory subunit of DNA fragmentation factor). Caspase-3 activation *in vitro* can be triggered by upstream events, leading to cytochrome c release from the mitochondria and subsequent activation of procaspase-9 by Apaf-1. Studies in rats showed that the upstream and downstream components of the caspase-3 apoptotic pathway are activated after contusive spinal cord injury and occur early in neurons in the injury site and hours or days later in oligodendroglia adjacent to and distant from the site of injury.[49] In our study, we saw the presence of necrosis and apoptosis mediators, such as caspase-3, whose manifestation is greater in groups with 12 h and 24 h NT injury, their reduced presence in the group with 24 h HT injury is statistically significant, which, in part, would be explained by the fact that cold and, in particular, CIRBP intervene in both apoptosis and cell death processes by blocking them.

CIRBP works by blocking several of these inflammatory cascades, cell death and apoptotic pathways. Although we did not attempt to mark all of these pathways in this study, we did observe that there are more viable neurons (immunopositive NeuN) in the HT group than in the NT groups, which is similar to those injured at 12 h versus 24 h in normothermia, indicating that this protein has most likely inhibited these cascades.

As limitations of the study, we must clarify that it was conducted with a small number of animals in order to adapt the research to the standards of good use and care of laboratory animals. Therefore, this research should be continued, increasing the sample size, as well as testing in other rat breeds and animal models, in order to translate this research into medical practice in the future.

GENERAL CONCLUSION

The use of cold therapy was associated with increased CIRBP expression and decreased death of motor neurons in the anterior horn of the spinal cord of injured rats. This encourages further research into cold therapy in spinal cord contusion injuries.

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Rehabilitation in Patients with Total Hip Arthroplasty During the Covid-19 Pandemic. Functional Outcomes

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ABSTRACT

Introduction: The COVID-19 pandemic had a significant impact on many parts of people's lives, including those who needed rehabilitation after primary hip arthroplasty. **Objective:** To determine if there is a difference in functional outcomes between supervised and self-administered rehabilitation after THA. **Materials and Methods:** Data were collected from two groups of patients: those who were operated on for unilateral THA and received supervised rehabilitation, and those who were operated on during the pandemic and experienced unsupervised, self-directed rehabilitation. The functional outcomes of both groups were compared three months and one year following surgery using the modified Harris Hip Score (mHHS) and the Forgotten Joint Score (FJS). **Results:** No significant differences were found in HHS between the two groups at 3 and 12 months (p 0.18). On the contrary, a statistically significant difference (p <0.001) was observed in the FJS, which was superior for unsupervised THA, both at 3 months and at 1 year. After 12 months, both scores showed significant improvement in the two groups (p < 0.001). **Conclusion:** After a THA, both supervised and unsupervised rehabilitation options should be considered. Our findings indicate that supervision does not result in faster or more successful rehabilitation, therefore enabling unsupervised rehabilitation for patients who require it.
Keywords: Total hip replacement; rehabilitation; functional outcomes; Forgotten Joint Score; Harris Hip Score; Covid-19.
Level of Evidence: IV

Rehabilitación en pacientes con artroplastia total de cadera durante la pandemia del COVID-19. Resultados funcionales

RESUMEN

Introducción: La pandemia del COVID-19 revolucionó muchos aspectos de la vida de las personas y aquellos pacientes que necesitaban una rehabilitación luego de una artroplastia total de cadera (ATC) no fueron la excepción. **Objetivo:** Determinar si existe alguna diferencia en los resultados funcionales entre la rehabilitación supervisada y la autoadministrada después de una ATC. **Materiales y Métodos:** Se recolectaron datos de 2 grupos de pacientes: los operados de ATC unilateral que realizaron rehabilitación supervisada y aquellos operados durante la pandemia, que recibieron rehabilitación sin supervisión, autoadministrada. Se compararon los resultados funcionales de ambos grupos a los 3 meses y al año de la cirugía mediante el Harris Hip Score modificado (HHSm) y el Forgotten Joint Score (FJS). **Resultados:** No se encontraron diferencias significativas en el HHS entre ambos grupos a los 3 ni a los 12 meses (p 0,18). Por el contrario, se observó una diferencia estadísticamente significativa (p <0,001) en el FJS, fue superior para la fisiokinesioterapia no supervisada, tanto a los 3 meses como al año. Ambos puntajes mejoraron a los 12 meses, en los dos grupos (p <0,001). **Conclusiones:** Tanto la rehabilitación supervisada como la no supervisada deben ser consideradas después de una ATC. Nuestros resultados han demostrado que la supervisión no implica una rehabilitación más pronta ni eficaz, esto otorga la posibilidad de una rehabilitación no supervisada para aquellos pacientes que así lo requieran.
Palabras clave: Artroplastia total de cadera; rehabilitación; resultados funcionales; Forgotten Joint Score; Harris Hip Score; COVID-19.
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INTRODUCTION

Total hip arthroplasty (THA) is a widely used surgical procedure to treat degenerative diseases of the hip joint. The number of THAs in the world has increased significantly in recent years as the population ages and musculoskeletal diseases become more prevalent.[1]

Today, postoperative physical therapy is considered indispensable to achieve favorable functional outcomes in the context of THA. The COVID-19 pandemic and the "Preventive and Compulsory Social Isolation" (ASPO) in force from March 20 to March 31, 2020, and finally until January 31, 2021,[2] transformed numerous aspects of people's lives, including those in need of rehabilitation after THA.

Some studies advocate for professionally supervised physical therapy, claiming that individualized treatment can lead to a successful recovery and better functional outcomes.[3-5] Other studies have found that self-administered exercise programs can be equally effective, and that patient autonomy in postoperative rehabilitation can be advantageous since it encourages self-responsibility and active involvement in the recovery process.[6,7]

However, the medical community continues to debate and disagree on the best approach to rehabilitation. Current scientific evidence provides conflicting results and has failed to clearly establish which of the two approaches, supervised or self-administered, is superior in terms of functional outcomes and long-term quality of life.

The aim of this study was to retrospectively compare functional outcomes at 3 months and 1 year in patients undergoing primary THA between two groups: those operated on during the pandemic period, who performed unsupervised self-administered rehabilitation, and those operated on before the pandemic, who received formal, professionally supervised rehabilitation.

Our hypothesis was that there would be no significant differences between the two groups after one year, but that the group receiving supervised physical therapy would have more favorable outcomes after three months.

MATERIALS AND METHODS

A retrospective analysis of functional outcomes was conducted in two groups of patients who had undergone THA: those who were operated on before the pandemic (2019) and had undergone the usual rehabilitation protocol implemented by the hip reconstructive surgery team for 12 weeks, supervised by a professional from the Rehabilitation Service, and those who were operated on during the pandemic (March 2020 to December 2021) and completed their rehabilitation at home, self-administered and unsupervised. Both groups followed the same exercise routine designed by the hospital's comprehensive rehabilitation team (Appendix).

The patients had been operated on by two expert surgeons from the same team, using a posterolateral approach.

Demographic data were evaluated, such as age, sex, side operated on, body mass index, comorbidities (chronic obstructive pulmonary disease, diabetes, coronary artery disease, smoking), type of implant and need for red blood cell transfusion after surgery (Table 1).

Functional outcomes were measured in both groups at 3 and 12 months after surgery using the modified Harris Hip Score (mHHS) and Forgotten Joint Score (FJS) (Table 2).

The inclusion criteria were: 1) age >18 years, 2) unilateral THA for hip osteoarthritis, Crowe types I and II hip dysplasia or femoral neck fracture, and 3) minimum follow-up of one year.

Appendix

HUA Rehabilitation Protocol

- **Hospitalization period:**
  Immediate postoperative period: Mobilization and exercise plan, isometric contraction of glutes and quadriceps, active mobilization exercises with flexion-extension of both hips, dragging the heel supported on the bed, and active and counter-resistance exercises for both feet.
  Post-operative day 1: Bedside sitting, standing and ambulation with a walker.

- **Post-discharge and first month:**
  Week 1: Mobilization plan and muscle and gait rehabilitation plan. Except in selected cases, canes and supports are not used.
  Weeks 2-4: Physical therapy twice a week. Exercise plan of 3 sets of 10 repetitions each. Passive and active mobilization plus progressive muscle strengthening.

- **From the 1st month onwards:**
  TENS or magnetotherapy are used for analgesic or anti-inflammatory physical therapy as needed by the patient. 10 min of stationary bike (high seat). A 1 kg load is added to the entire exercise plan. Assisted active exercises in lateral decubitus for abductors. Psoas elongation.

- **From the 2nd month onwards:**
  Lightweight quadriceps chair exercises. 10 min of treadmill walking.

- **From the 3rd month onwards:**
  Same protocol, additional load according to tolerance. Low impact aerobic activity.

Table 1. Demographic variables

Variable*	Unsupervised physical therapy	Supervised physical therapy	p
n	**60**	**47**	
Male sex, n (%)	36 (60.0)	25 (53.2)	0.611[1]
Age	62.02 (12.03)	62.55 (11.03)	0.813[1]
Left side, n (%)	27 (45.0)	29 (61.7)	0.128[2]
Type of implant, n (%)			0.447[2]
Cemented	7 (11.7)	6 (12.8)	
Hybrid	2 (3.3)	0 (0.0)	
Uncemented	51 (85.0)	41 (87.2)	
Body mass index	28.41 (5.03)	29.16 (5.27)	0.453[1]
Other lower limb arthroplasty, n (%)	6 (10.0)	6 (12.8)	0.888[2]
Chronic obstructive pulmonary disease, n (%)	3 (5.0)	0 (0.0)	0.335[2]
Coronary heart disease, n (%)	9 (15.0)	5 (10.6)	0.708[2]
Transfusions, n (%)	2 (3.3)	0 (0.0)	0.586[2]
Smoker, n (%)			0.738[2]
Ex-smoker	6 (10.0)	7 (14.9)	
No	44 (73.3)	33 (70.2)	
Yes	10 (16.7)	7 (14.9)	
Diabetes, n (%)	6 (10.0)	1 (2.1)	0.215[2]

*Continuous variables summarized as mean (standard deviation).
[1]Kruskal-Wallis test; 2Fisher's test.

Table 2. Functional outcomes.

	Unsupervised physical therapy	Supervised physical therapy
Modified Harris Hip Score		
3 months	79.6	82
1 year	84.9	87.3
Forgotten Joint Score		
3 months	86.9	70
1 year	91.1	75.7

The exclusion criteria were: 1) THA for Crowe types III and IV dysplasia, 2) absence of data on mHHS and FJS in the clinical records, 3) primary arthroplasties complicated by dislocation, periprosthetic infection or periprosthetic fracture that modified the usual postoperative period, 4) symptomatic COVID-19 patients who required rest or hospitalization.

The data were collected through a search in the computerized clinical record system of our institution, the "PECTRA System".

Statistical Analysis

The Kruskal-Wallis test for continuous variables and Fisher's test for categorical variables were used to compare mHHS and FJS values at 3 and 12 months postoperatively in the supervised and self-administered physical therapy groups. The demographic data of the sample were also analyzed. A p value <0.05 was considered significant.

RESULTS

The medical records of 272 patients undergoing THA were reviewed, with 119 receiving supervised physical therapy in 2019 and 147 receiving unsupervised physical therapy during the pandemic. 165 patients were excluded: 127 for incomplete clinical record data, 27 for symptomatic COVID-19 that interrupted rehabilitation, six for implant dislocation, four for periprosthetic infection, and one for periprosthetic fracture.

Finally, 107 patients undergoing THA were included: 47 patients received supervised physical therapy (operated in 2019, before the pandemic), while 60 patients received self-administered rehabilitation at home (operated between March 2020 and December 2021). The mean age in both groups was 62 years. No significant differences in demographic variables were observed between the groups (Table 1).

The mean mHHS at 3 months after surgery was 79.6 (95% confidence interval [95%CI] 77-82.2) for patients with unsupervised physical therapy, and 82 (95%CI 79.1-84.9) for those who did supervised physical therapy. At 12 months, the mean scores were 84.9 (95% CI 82.3-87.4) and 87.3 (95% CI 84.3-90.2), respectively. The difference in score at 3 and 12 months was 2.37 (standard error 1.76; p 0.18), in both groups (Figure 1).

The mean FJS at 3 months after surgery was 86.9 (95%CI 82.4-91.5) for patients with unsupervised physical therapy, and 70 (95%CI 65.2-74.8) for those in the other group. At 12 months, the means were 91.1 (95% CI 86.6-95.7) and 75.7 (95% CI 70.9-80.4), respectively. The difference in score at 3 months was 16.9 (standard error 2.09; p<0.0001), while at 12 months it was 15.5 (standard error 2.09; p<0.0001) (Figure 2).

The difference between the score at 3 and 12 months was 4.2 (p<0.0001) in patients with unsupervised physical therapy and 5.67 (p<0.0001) in those with supervised physical therapy.

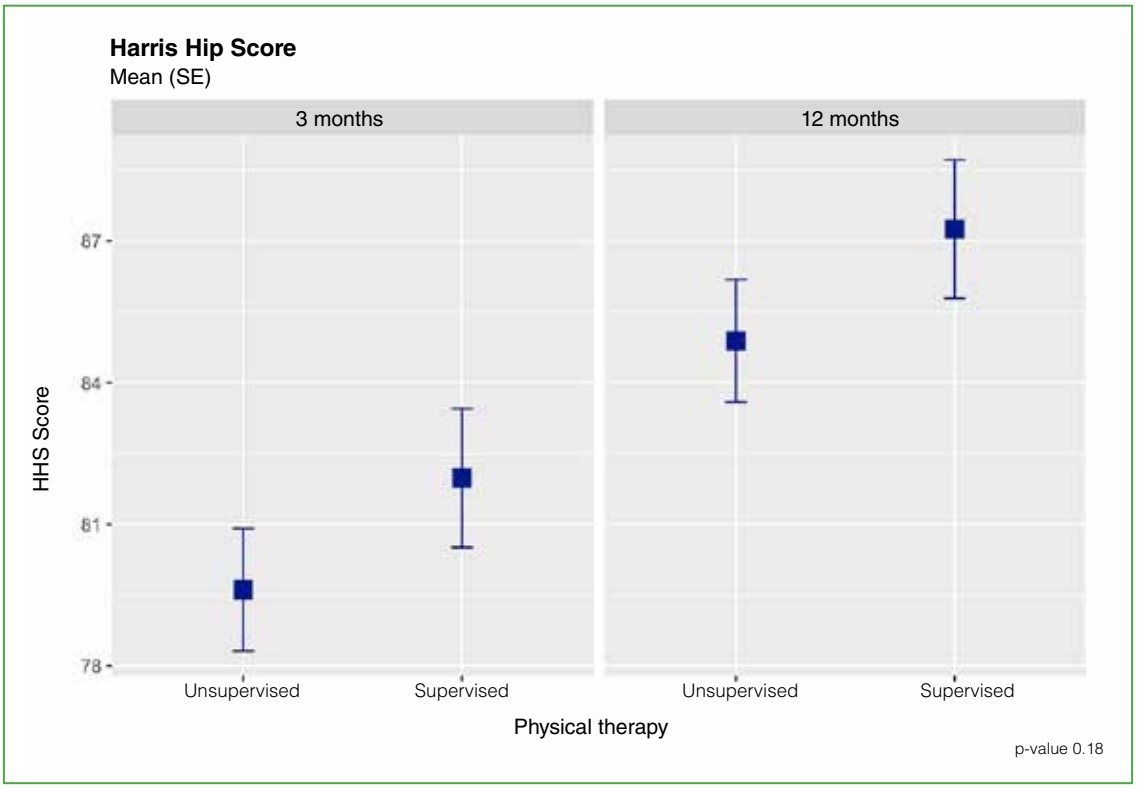

Figure 1. Harris Hip Score results at 3 and 12 months.

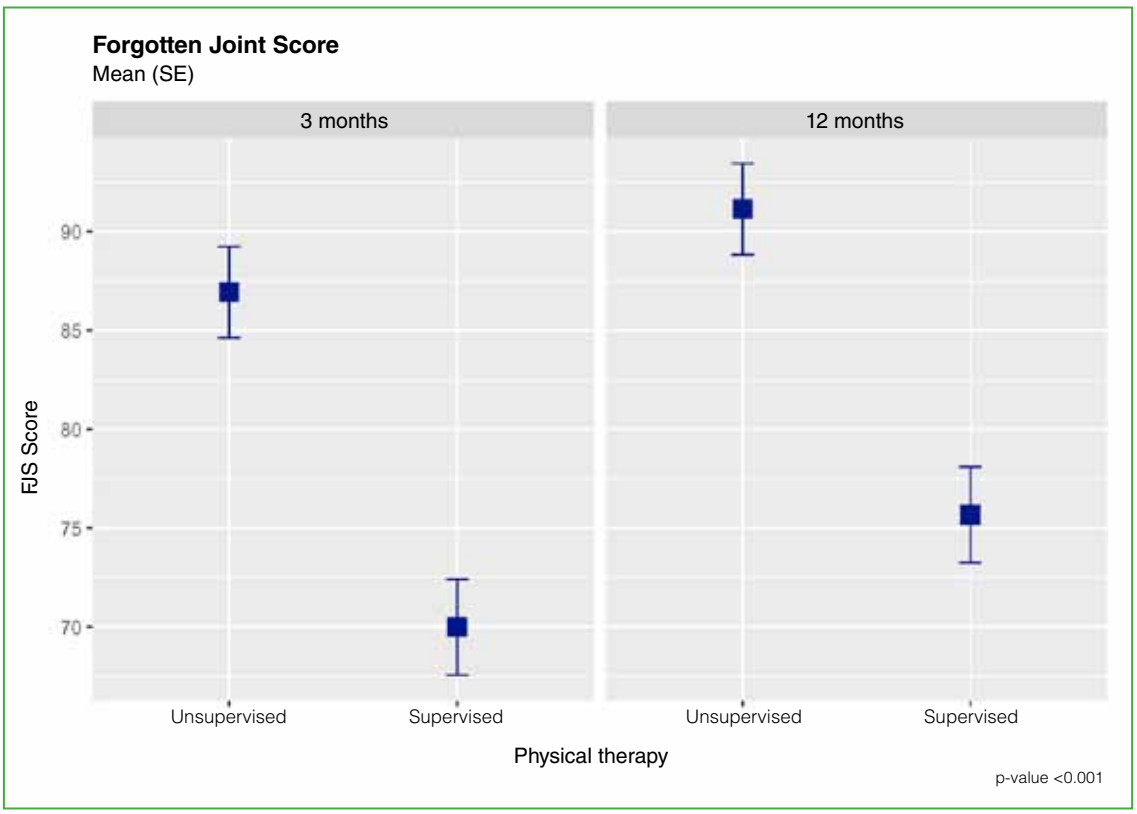

Figure 2. Forgotten Joint Score results at 3 and 12 months.

DISCUSSION

Supervised kinesiology rehabilitation has long been considered the gold standard in the postoperative management of patients undergoing THA. Several studies have highlighted its benefits in improving functional outcomes and reducing disability in patients. Furthermore, because kinesiologists provide each patient individualized care, the rehabilitation program may be tailored to meet the specific requirements of each patient, leading to a more effective and successful recovery.[8-10] However, self-administered exercises have also gained recognition as a viable option in the rehabilitation process following THA.[11]

Regarding the results of our study, mHHS scores were higher in the supervised rehabilitation group, both at 3 and 12 months, with no statistically significant differences (p 0.18). These findings are consistent with those of Coulter et al.,[12] who, in their randomized, controlled study, found no clinical or statistical differences in scores on the WOMAC *(Western Ontario McMaster Universities Osteoarthritis Index*) scale, the SF-36 questionnaire and the *Timed Up and Go* test at 6-month follow-up between a self-administered group and a supervised rehabilitation group. These authors concluded that an unsupervised early rehabilitation plan can be developed effectively for low-risk patients. On the other hand, Saueressig et al.[13]discovered no advantage of supervised physical therapy over standard postoperative care or any other type of care.

With respect to the FJS, our study found no statistically significant difference ($p<0.0001$) in favor of the self-administered rehabilitation group, both at 3 and 12 months. Likewise, statistically significant improvements in the FJS were observed within each group between 3 and 12 months postoperatively: a 4.2-point difference for the self-administered physical therapy group and a 5.67-point difference for the supervised physical therapy group. However, none of these values reached the minimum significance difference for the score in question, which is set at 10.8 points. These findings, although contradictory, reinforce the aforementioned statements about the favorable and reproducible results of self-administered home rehabilitation. In their 2008 randomized clinical study, Galea et al.[11] found no significant differences between patients who underwent rehabilitation in specialized centers and those who followed specific self-administered plans after THA. In their study, both rehabilitation groups showed significant improvements in quality of life, ability to walk up and down stairs, the *Timed Up and Go* test, and the 6-minute walk test eight weeks after surgery. These authors concluded that a strengthening plan is effective and generates significant improvements for patients, whether in a rehabilitation center or at home.

In terms of economics, Fatoye et al. studied the cost-effectiveness of physical therapy following total hip arthroscopy (THA) and found that, from the perspective of national health systems, physical therapy was only cost-effective when carried out in accelerated programs. However, they were unable to extrapolate these findings to the level of the patient or healthcare provider.[14]

Making an informed decision requires careful consideration of the benefits and limitations of each type of rehabilitation. Supervised kinesiology rehabilitation offers the advantage of direct supervision by trained professionals, ensuring proper technique correction, optimal exercise progression and individualized attention. On the other hand, self-administered exercises offer the advantage of autonomy and flexibility for the patient, which may improve compliance with the rehabilitation program and overall satisfaction.[9,15,16] In addition, self-administered exercise programs may be more accessible and cost-effective, especially for those patients who have geographic limitations or financial difficulties in accessing supervised rehabilitation services.

A strength of our study is that, to our knowledge, it is the first to compare functional and subjective outcomes in groups with different types of rehabilitation after THA in Argentina. The sample is acceptable. Limitations include its retrospective design and the fact that it was not possible to include many patients due to the lack of information in the clinical records. The FJS reflects the subjectivity of each patient, unlike the mHHS, which includes both a subjective and an objective component.

CONCLUSIONS

Our study yielded no statistically significant differences in the mHHS at 3 and 12 months post-surgery between a supervised and a self-administered rehabilitation plan. However, significant differences were found in the FJS: self-administered rehabilitation was superior at both 3 and 12 months, most likely due to the full subjective nature of the score and the epidemiological context in which this group's THA was performed. This supports the growing controversy in the rehabilitation field and underscores the importance of considering each patient's preferences and needs when deciding on the most appropriate rehabilitation approach. Future high-quality research with larger cohorts are required to corroborate our findings and provide more precise recommendations for clinical practice.

Conflict of interest: The authors declare no conflicts of interest.

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Elbow Trauma. Review of Argentine Contributions: From 1956 to the Present Time Anniversary of the AAOT Library Service

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ABSTRACT
The library service and the Journal are the pillars of the Argentine Association of Orthopedics and Traumatology. We provide national and international authors with international visibility through publication and indexing. The objective of this presentation is to discuss some of our country's peers' contributions and experiences with elbow surgery and conditions in the AAOT Journal and other international publications.
Keywords: Distal humerus fractures; elbow instability; elbow dislocation; olecranon fractures; total elbow arthroplasty; elbow trauma.
Level of Evidence: V

Traumatología de codo. Reseña de aportes argentinos: desde 1956 hasta la actualidad Aniversario del Servicio de Biblioteca de la AAOT

RESUMEN
El Servicio de Biblioteca y la Revista se constituyen en pilares de la Asociación Argentina de Ortopedia y Traumatología. Publicando e indexando se logra una exposición internacional para los autores nacionales e internacionales. El objetivo de esta presentación es reseñar algunos aportes de colegas de nuestro país a la cirugía y afecciones del codo en la RAAOT y otras publicaciones internacionales.
Palabras clave: Fracturas de húmero distal; inestabilidad de codo; luxación de codo; fracturas de olécranon; prótesis de codo; traumatología de codo.
Nivel de Evidencia: V

INTRODUCTION

It has been 40 years since the creation of the AAOT Library Service. I had the honor of chairing the Library Committee as it celebrated its 30th anniversary, between 2013 and 2017,[1] following Dr. Alejandro José Ramos Vértiz.. In those days, I had the pleasure to observe directly the tireless effort of Veronica Mauceri and Silvina Dicranian. Among other things, they digitized the AAOT journal in its entirety, and collaborated with indexing by providing information to LILACS and other sources on a regular basis. Furthermore, they preserved and classified an invaluable collection of publications from all areas of the specialty.

The current Journal of the Argentine Association of Orthopedics and Traumatology (in Spanish, RAAOT), originally known as the Bulletin of the Argentine Society of Orthopedics and Traumatology, is one of the Association's pillars. It is currently published digitally in Spanish and English, with extensive indexing as a result of meeting numerous international standards. The metrics indicate that it reaches readers from all around the world. All of this is due to the efforts of the Editorial Committee, led by Dr. Ernesto Bersusky and Dr. Lidia Loterzo. National authors, as well as authors from various countries, have been publishing for almost 80 years and continue to rely on the AAOT Journal to promote their work.

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The objective of this article is to review some of our country's contributions on elbow surgery and pathology in the AAOT Journal and other international publications. Given the volume of content and the limited length of this article, we do not plan to cover all authors or topics. For example, the topic of stiff elbow has not been addressed. Perhaps this topic, along with others by different authors, will be the focus of future publications.

The elbow is one of the most recently studied joints, therefore, its interpretation for diagnosing and treating its numerous disorders has improved. Clinical and laboratory studies have contributed to the knowledge of the elbow's physiology, biomechanics, force transmission, mobility, and stability. These investigations led to the development of specific implants to treat different fractures (regional plates, screws with appropriate diameters, etc.), total and partial prostheses, and radial head prostheses, as well as surgical techniques for ligament reconstruction or joint release. In addition, arthroscopic techniques have been developed to aid or treat a wide range of diseases.

DISTAL HUMERUS FRACTURE

For much of the twentieth century, the debate over distal humerus fractures centered on conservative treatment versus osteosynthesis. Non-surgical treatment was based on reductions, skeletal tractions and casts. On the other hand, surgical outcomes were variable and constrained by a scarcity of appropriate implants.[2-4]

Over the last two decades, distal humerus osteosynthesis has advanced in terms of available implants, such as locking plates and screws that are anatomically premolded to the complex bone anatomy.

In 2005, a study of 16 patients treated with different types of osteosynthesis was published. An average humeroulnar joint range of motion of 98° was obtained. Elbow flexion averaged 117°, while loss of elbow extension averaged 22°.[5]

In 2008, Gallucci et al. published a series of distal humerus fractures treated with nonanatomic locking plates. In their study, they retrospectively evaluated 17 patients (average age 59 years) with a minimum follow-up of one year. Twelve had type C AO fractures, and five had type A fractures. The average follow-up was 23 months. The range of motion obtained was between 15º and 135º, with a total arc of motion of 120º. The results were excellent in 11 patients, good in five, and fair in one.[6]

In recent years, different authors have reported their outcomes with locking regional plates.

In a special issue of 2022 in collaboration with the Asociación Argentina de Hombro y Codo, Muñoz and Rosso Guiñazu evaluated 19 cases treated with premolded locking plates. In that series, consolidation of all fractures was achieved. The Alonso Llames approach was used in seven patients (37%) and olecranon osteotomy in 12 cases (63%). The average DASH (Disabilities of the Arm, Shoulder and Hand) score was 11.31, indicating mild disabilities. The MEPS (Mayo Elbow Performance Score) obtained was excellent in one patient (5.26%), good in 10 (52.6%), fair in seven (36.84%) and poor in one (5.26%).[7]

To achieve successful outcomes in these complex fractures, surgical technique should be focused not only on the right use of implants, but also on technique and rehabilitation..[8,9]

We evaluated a series of cases in which we performed osteosynthesis using the paratricipital approach as an alternative to olecranon osteotomy for some fractures. This approach was useful for supracondylar fractures, but also for simple articular fractures. With a mean follow-up of 3.4 years, the mean flexion-extension range was 138.3°; mean MEPS was 85.8; mean DASH score was 11.8; and mean visual analog pain scale score was 1.3. All fractures healed (Figure 1).[10]

OLECRANON FRACTURE

Numerous authors have studied olecranon fractures, which are articular fractures that also involve one of the elbow's stabilizers (the humeroulnar joint). Dr. Eduardo Cossavella Senac proposed the use of an intramedullary screw 11 to 15 cm long and 5 to 5.5 mm in diameter in 1974, citing his experience with 27 patients.[11]

On the other hand, conservative treatment has been proposed in patients >70 years of age and with low functional demand, with mostly satisfactory outcomes. Eighteen patients were evaluated of whom 24 progressed to nonunion; however, flexion-extension was 142°-15°. Muscle strength was M5 in 17 patients and M4 in nine. A fist strength of 93% was obtained on the contralateral side. Pain according to the visual analog scale was 1. Satisfaction with treatment, according to this scale, was 9. According to the Mayo Clinic score, the outcomes were excellent in 22 patients and good in six. The average DASH score was 15.[12]

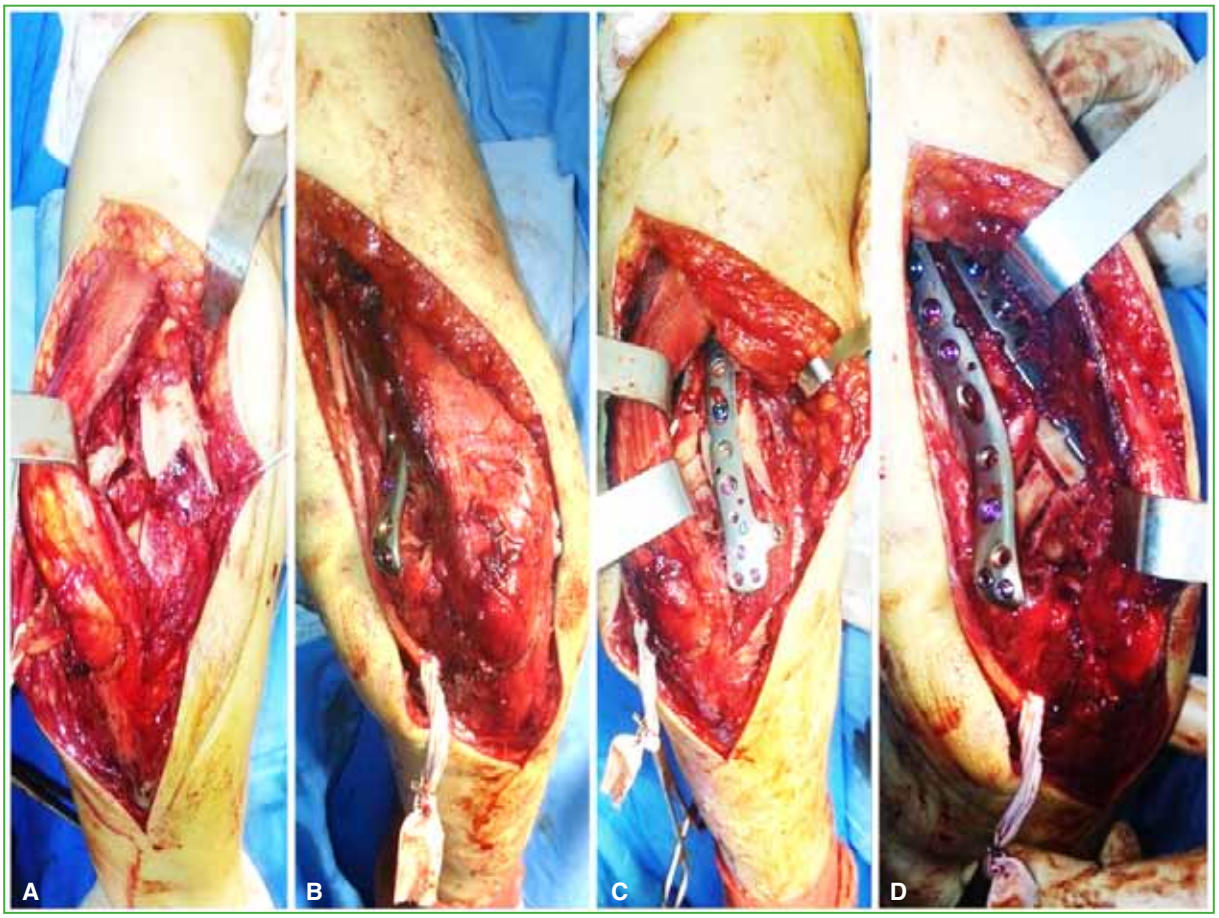

Figure 1. A. View of the fracture through the paratricipital approach. **B.** View of the medial distal humerus. **C.** View of the lateral distal humerus. **D.** View after placement of two plates in orthogonal arrangement.

Recently, Dr. Cabrera and Dr. Caló proposed associating high-strength sutures with cannulated screws instead of wires, and the outcomes obtained were satisfactory. Six months after the operation, the average flexion was 143° (range 90°-160°) and the average extension was 19° (0°-55°).[13]

In 2020, we investigated the long-term complications of surgically treated olecranon fractures. We assessed 42 cases, with an average follow-up of 43.64 months. Eighteen patients (42.86%) were treated with regional locking plates, 21 (50%), with traction-absorbing wiring, and three (7.14%) with 7 mm cannulated screws and traction-absorbing wiring. Six of these patients (14.29%) required implant removal. There were no cases of nonunion. More complex fractures were associated with osteoarthritic changes (14 cases, 33.3%), but these did not influence clinical outcomes, as they were not significantly associated with scores (MEPS, DASH), residual pain (visual analog scale) or loss of range of motion.[14]

MONTEGGIA FRACTURE

In 1956, Dr. José Luis Bado, a Uruguayan surgeon, described his classification of Monteggia's fractures and dislocations in the Bulletin of the Argentine Society of Orthopedics and Traumatology. He classified them into four groups and identified injuries that he considered equivalent. This classification was based on the observation of 55 cases. This classification is still recognized in the international literature on the subject.[15] Dr. Alberto Caneva first reported the reduction maneuvers for these complex injuries in 1966.[16]

TRAUMATIC SEQUELAE. MALUNION. NONUNION

Posttraumatic cubitus varus is a long-term complication of supracondylar humerus fractures in children. In 1966, Dr. Carlos Ottolenghi published, in detail, the lateral closed wedge osteotomy technique for the treatment of cubitus varus.[17]

Late ulnar nerve neuritis has been reported as a complication related to cubitus varus.[18] We have also observed posterolateral rotatory instability as a late complication of varus malposition of fractures healed in infancy.[19]

A few years ago, a report on treatment for cubitus valgus as a sequelae using closed osteotomy was published. In five patients with an average follow-up of 17 months, the average valgus was corrected from 30º (contralateral of 11º) to 13º. The Oppenheim scale indicated that the outcome was excellent in four cases and good in one.[20]

Undoubtedly, distal humerus nonunion, especially when it is recalcitrant, is one of the most difficult complications to solve. Dr. Carlos Zaidenberg proposed a technique involving vascularized bone grafting. In an average of 16 months, consolidation was achieved in the seven cases evaluated.[21]

In 2008, Dr. Allende et al. reported their long-term outcomes (average 46 months) in 24 cases of distal humerus nonunion treated with different types of osteosynthesis. Consolidation was achieved in all cases within five months after surgery.[22]

DISLOCATIONS AND INSTABILITY

Acute or chronic elbow ligament injuries have been better diagnosed and treated in recent decades, as research has increased. Identifying the stabilizers and their injuries is critical for therapeutic planning.[23]

Chronic posterolateral rotatory instability, as described in 1991 by O'Driscoll, must be suspected in order to diagnose it and plan its treatment. In these cases, ligament reconstruction is necessary.[24] In certain cases, depending on the time of evolution and the number of episodes of dislocation, it is accompanied by an impaction fracture of the capitellum, as described by Osborne and Coterill in 1966. It is not always necessary to treat this bone defect with a graft and reconstruction, even if the radius is locked following dislocation (Figure 2).[25]

Different techniques have been developed for ligament reconstruction in cases of chronic medial elbow instability. In 2010, Slullitell and Glasberg proposed a medial reconstruction with a new technique using the fascia of the extensor carpi ulnaris in 12 cases.[26]

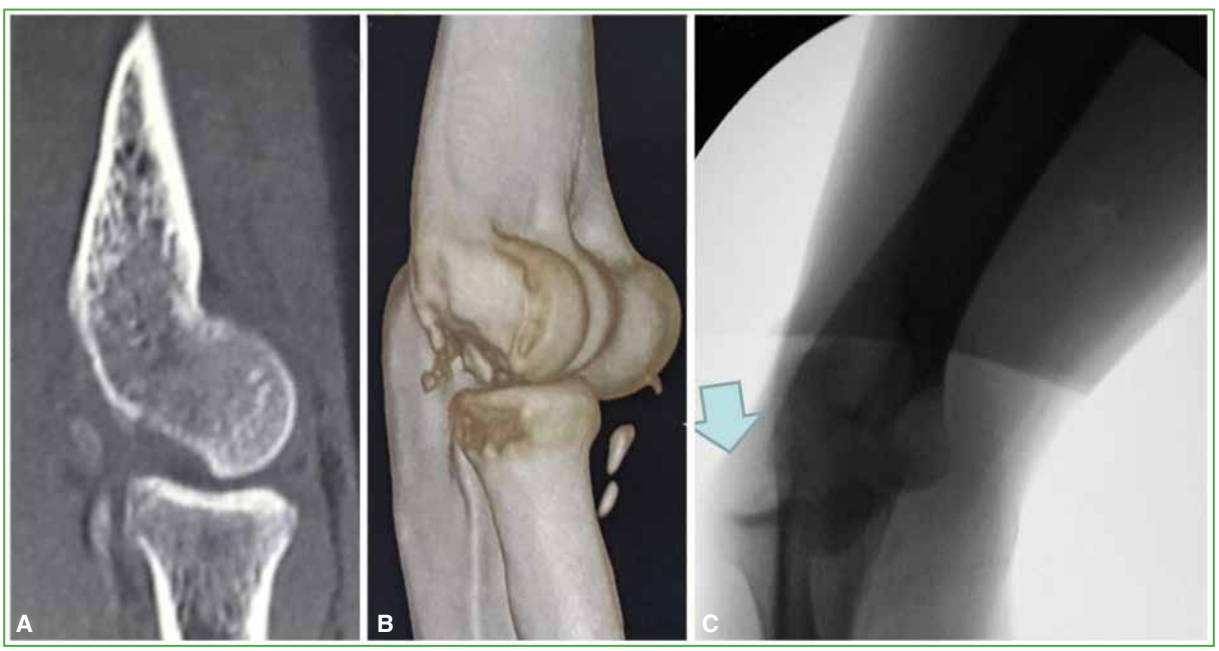

Figure 2. A and B. Computed tomography. Impaction fracture of the capitellum after posterolateral dislocation. **C.** Fluoroscopy. The locking of the proximal radius is seen during a *pivot shift* maneuver due to posterolateral rotatory instability.

DISTAL BICEPS

In recent years, the incidence of complete distal biceps tears appears to have increased. In young, active patients, superior outcomes have been achieved with repair than with conservative treatment. The options for single or double approaches and fixation are varied (harpoons, transosseous sutures, bio-tenodesis, buttons).

Capomassi et al. evaluated a series of 17 cases treated with double fixation using an anterior approach with an extracortical button and bio-tenodesis screw. With an average follow-up of 12 months, the outcome was excellent in 15 patients and good in two (according to DASH and Andrews-Carson scores). All patients achieved M5 strength for forearm flexion and supination.[27]

TOTAL ARTHROPLASTY

The complication rate of total elbow arthroplasty was high with the first models and was an option only in cases of severe sequelae.[28,29] In the first published series, the outcomes were lower than with resection arthroplasties.[30] The advent of semi-constrained designs with the possibility of lateral motion in addition to flexion-extension improved long-term outcomes.[30]

The initial indications were degenerative diseases, such as primary osteoarthritis and rheumatoid arthritis, but, as reported in a review we published in 2012, the indication in unreconstructable fractures of the distal humerus has increased exponentially, mainly in the United States, Canada and Europe (Figure 3).[31] There appears to be a consensus and predictable outcomes for the treatment of unreconstructable distal humerus fractures with total elbow arthroplasty in patients >65 years of age.[32]

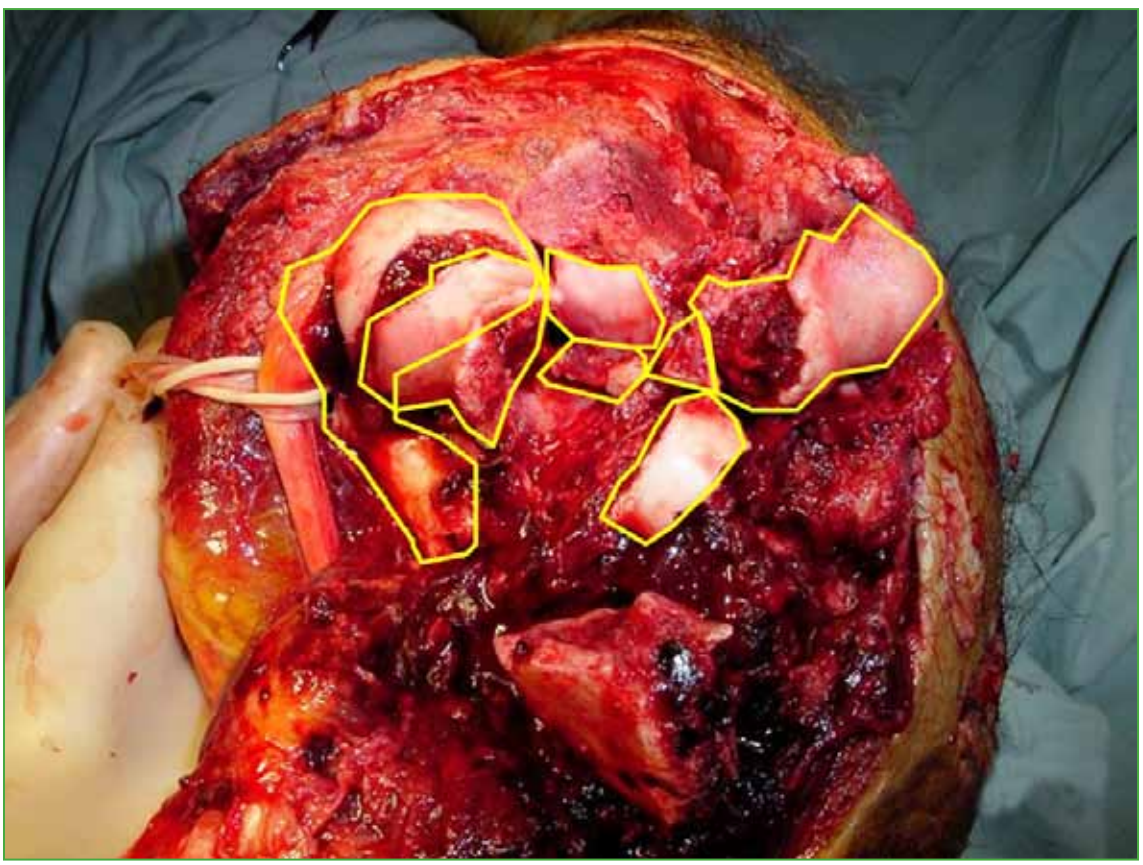

Figure 3. Complex fractures in the elderly: prosthesis or osteosynthesis? Intraoperative image of a comminuted fracture of the distal humerus.

The annotated articles are available in the AAOT library. In addition, AAOT Journal articles can be freely accessed at: https://raaot.org.ar/index.php/AAOTMAG/index

Conflict of interests: The author declares no conflicts of interest.

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Dr. Eduardo A. Zancolli (1924-2024)

A few days before Dr. Eduardo Zancolli's death, I was drafting a note to honor his upcoming birthday; it would be a memorable occasion: it would be his centenary.

It is unusual for traumatologists to reach the age of one hundred; as of yet, this is a normal human condition.

So why write a note before such an unusual circumstance?

When we received the news of his death, and the note of appreciation prior to his centenary had not yet been published, our first thought was: "*we were too late*," "*it would have been better to publish it earlier*."

After the initial impression, and when comparing the content between the note prior to his death and the current one, I find coincidences:

- We acknowledge his dissemination of the semiology systematization of numerous nosological entities.
- He set a high standard for substantiating indications and techniques in Morphological Sciences.
- He was a disciplined surgeon and adhered to the Finochietto School.

We celebrate life, as well as the virtues that do not expire with a human being; rather, they encourage those who choose to follow in the master's footsteps.

I pay tribute to Dr. Eduardo Zancolli, who continues to teach.

Dr. Carlos María Autorino
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Dr. Carlos Eduardo Nemirovsky 1943-2024

Today, with enormous sadness, I write the obituary for my dear friend and companion of 52 years. I met Carlos Eduardo Nemirovsky in 1972, it was at my first AAOT conference, I was impressed by his presentation and tried to communicate with him.

Two years later, when I joined the Anatomy laboratory led by our teacher, Dr. Elbio Pedro Cozzi, we began working on anatomical research and intensive study of Orthopedics and Traumatology; at first, we were hand surgeons, and then, on the Master's recommendation, we dedicated ourselves to the study of foot pathology. He was extensively involved in the Society for Foot Medicine and Surgery, where he served as vice-president (1995-1996) and president (1997-1998). We worked together in the Orthopedics and Traumatology Service led by Dr. Pascual Sturniolo for 35 years. The work was demanding, not only in terms of healthcare practice, but we also published 50 research papers at the national and international level. When Dr. Cozzi died, we founded the Foundation for Anatomical and Biomechanical Research, which Carlos chaired and I supported; since then, several anatomical research papers have been published at several specialty conferences. We founded the Orthopedics and Traumatology Service of the San Martín Medical Corporation, whose leadership he held until the time of his departure. Carlos was an excellent surgeon, possibly the most talented I had seen in all these years. His extensive knowledge of anatomy enabled him to operate neatly, dexterously, and in much shorter surgery times than other surgeons. I learnt to study and operate in our specialty alongside him, we shared trips and family reunions, and he was the older brother I did not have.

You instilled in me a reading culture that was unique to you. My dear friend, the ailment you suffered caused you a great suffering that you did not deserve, but you did so with the integrity that characterized you throughout your life. You left behind friends and students who will always remember you with love and respect. We fought hard and we did it with pleasure; I admire you and I carry you with me in memory of those who gave their all for the sake of learning. May the Creator give you a place among the righteous.

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