DOI:10.2478/tperj-2020-0013

The benefits of the TECAR therapy in flexion recovery after revision of the anterior cruciate ligament (ACL)

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Abstract

Purpose: The following research highlighted the importance of the TECAR therapy in recovering after anterior cruciate ligament surgery in performance athletes. *Methods:* The study took place at *Fizionova* Medical Recovery Center in Targu Mures, on a period of 6 weeks between 24.01.2020 and 07.03.2020, on a sample of 10 subjects with anterior cruciate ligament surgery (5 subjects in the experiment group that followed the TECAR recovery program and 5 subjects that only followed a physiotherapy program for recovering from anterior cruciate ligament surgery), 7 male subjects and 3 female subjects with ages between 24 and 44 years. The research method was mostly experimental. We worked with TECAR therapy, muscular electrostimulation, and a series of kinesiotherapy exercises. For the statistical interpretation, we used the GraphPad Prism program using the Shapiro-Wilk test, t-Student test, Mann-Whitney, and Wilcoxon tests. *Results*: The results of the investigation showed statistically significant differences between the experiment and control group after 4 and 6 weeks of a TECAR and kinesiotherapy recovery program. *Conclusions*: The conclusions of our investigation highlighted the importance of implementing a supplementary kinesiotherapy program using the TECAR therapy in athletes who recover from anterior cruciate ligament surgery.

***Key words**: TECAR therapy, anterior cruciate ligament recovery, kinesiotherapy.*

Rezumat

Scop: Prezenta cercetare a evidenţiat importanţa terapiei TECAR în recuperarea după operaţia ligamentului încrucişat anterior la sportivii de performanţă. *Metode*: Studiul a avut loc la Centrul de Recuperare Medicală *Fizionova* din Târgu Mureş, pe o perioadă de 6 săptămâni între 24.01.2020 - 07.03.2020, pe un eşantion de 10 subiecţi care se aflau în recuperare după operaţia chirurgicală de ligament încrucişat anterior (5 subiecţi din grupul experiment, cu care am lucrat cu program de recuperare TECAR, şi 5 subiecţi care au urmat doar programul de fizioterapie pentru recuperarea după operaţia chirurgicală la ligamentului încrucişat anterior), 7 subiecţi de sex masculin şi 3 subiecţi de sex feminin, cu vârsta cuprinsă între 24 şi 44 de ani. Metodele de cercetare au fost în mare parte experimentale. Am lucrat cu terapia TECAR, electrostimulare musculară şi o serie de exerciţii de kinetoterapie. Pentru interpretarea statistică am folosit programul GraphPad Prism, folosind testul Shapiro-Wilk, testul t-Student, Mann-Whitney şi Wilcoxon. *Rezultate*: Rezultatele investigaţiei au arătat o diferenţă semnificativă statistic între grupa experiment şi grupa de control după o perioadă de 4 şi 6 săptămâni de urmare a programului TECAR de kinetoterapie pentru recuperare. *Concluzii*: Concluziile investigaţiei noastre au evidenţiat importanţa implementării unui program kinetoterapeutic suplimentar cu terapie TECAR la sportivii care se recuperează după operaţia chirurgicală la ligamentului încrucişat anterior.

***Cuvinte cheie**: terapia TECAR, ligamentul încrucişat anterior, kinetoterapie.*

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Introduction

The outer portion of the medial meniscus is firmly attached to the joint capsule and deep fibers of the medial collateral ligament, making it less mobile than the lateral meniscus, which does not connect to the lateral collateral ligament and attach weakly to the articular capsule [1]. In addition to their connections to the tibial plateau through the anterior and posterior horns, the two anterior edges of the menisci are connected by the transverse intermeniscal ligament [2]. Several thousand anterior cruciate ligament revision surgeries are conducted yearly and, sadly, they are correlated with inferior clinical consequences. During this, patients would be provided proper guidance on their presumptions and rehabilitation objectives proposed by specialists as this previous cruciate ligament revision intervention requires a more extended rehabilitation period [3].

A rigorous and meticulous approach should be used for patients who have suffered a failure in the primary reconstruction of the anterior cruciate ligament, following which patients will benefit from satisfactory results. However, even in the best circumstances, the revision of the anterior cruciate ligament is associated with significantly lower clinical outcomes than the primary reconstruction of the anterior cruciate ligament [4].

The surgical technique errors represent most of the problems that occurred after the primary reconstruction of the anterior cruciate ligament. The too prevalent technical mistake is the inappropriate arrangement of the tunnel with the native femoral and tibial fingerprints. This anterior posting of the femoral tunnel results in extreme graft discomfort during flexion, triggering a drop of knee flexion or graft stretching. A posterior femoral tunnel response results in inflated graft discomfort, although the knee is in incomplete extension, through laxity in flexion [5].

Preoperative planning is crucial to ensure a successful revision surgery. A detailed medical history of the patient is needed, emphasizing the activity level, injury mechanism, and antecedent symptoms. The patient should also be consulted for previous joint damage, a history of coagulation disorders, risk factors for osteoporosis, and any history of generalized ligament laxity or connective tissue disorders.

Actions that must be initiated instantly after surgery to increase quadriceps stamina incorporate muscle electrostimulation, patellar mobilizations, hip flexion and extension, and dorsal and plantar flexion [6].

A full spectrum of movement would be performed within six weeks, and closed kinetic chain workouts must be commenced. At some point, the patient would load his/her weight on both lower limbs, and the graft must be powerful to proceed to close kinetic chain exercises. The initiation of sprinting and more energetic movements that feature pivoting must be postponed until after at least six months, relying on the patient's condition and cause of the failure of primary reconstruction [6].

Returning to previous athletic activities would not be launched until the physiotherapist's goals have been achieved. These refer to the optimal muscle strength of the lower limbs, regaining balance, and also proprioception. It is not recommended to return to competitive play earlier than 9–12 months postoperatively.

To have satisfactory results, it is recommended to combine several techniques such as electrotherapy, the physical therapy program itself combined with proprioception exercises, a device of continuous passive movement in the first weeks of recovery, and subsequent hydrotherapy.

The TECAR therapy (capacitive and resistive energy transfer) is an endogenous thermotherapy process that employs electrical tides, triggered by a capacitive/resistive monopolar radiofrequency of 448 kHz producing profound tissue heat [7]. Most studies on the effects of the TECAR therapy have noted promising outcomes in diminishing pain and enhancing function in various musculoskeletal medical disorders such as back discomfort, Achilles tendon insertional tendinopathy, patellar, and common tendons of radiocarpal joint extensors [8]. Due to its thermotherapeutic implication, its ability to influence blood flow is widely considered a path in which the TECAR therapy encourages the therapeutic procedures of wounded / dysfunctional tissues [9].

The TECAR device provides two distinct therapy settings: capacitive (CAP) and resistive (RES). These methods are usually distributed with various probes (electrodes) made of medical stainless steel. When the active electrode is supplied through an

insulating ceramic coating that behaves as a dielectric medium (CAP), the energy spread sparks only heat in exterior tissue coverings, with a specific behavior on gentle tissues with soft impedance. When the active electrode does not contain an insulating coating (RES), the radio frequency power travels automatically through the body in the direction of the nonoperational electrode, producing heat in the more profound and more resistant (low water content) tissue coverings [10] The TECAR therapy is a combination of combined electrotherapy and touch diathermy. This form of physiotherapy applies electromagnetic energy to the biological tissue. The applied electromagnetic energy comes from the radio frequency spectrum. Unlike other electrotherapy procedures, it does not cause muscle contraction.

Material and method

Hypothesis of the research

Following the surgery for the revision of the anterior cruciate ligament, the patients who benefited in the first six weeks from a personalized recovery program, developed by us, combined with TECAR therapy, performed both statically and dynamically, reached optimal flexion degrees faster compared to patients who only benefited from the kinetic recovery program.

Objectives of the research

The overall objective of this research is to demonstrate the effects of the TECAR therapy in the first weeks of recovery after the revision of the anterior cruciate ligament. It is also essential to present the importance of re-educating the flexion deficiency that occurred after surgery.

Methods of research

In this research, we used the following research methods: the case study method, the observation method, the graphic method, the statistical-mathematical method.

All patients followed the same kinetic recovery protocol, except that 5 of them had introduced the TECAR dynamic and static therapy. The equipment used: physiotherapy room, TECAR Globe DIACARE 5000, Compex SP 8.0, ARTROMOT, elastic bands, bosu ball, stepper, press, 30 cm box, fitness ball, walking line.

The multidisciplinary team was made up of a doctor, a nurse, a team of specialists from the Fizionova Recovery Center: physiotherapist, orthopedist, psychologist. We would like to mention that the ten patients included in the study agreed to participate, actively or passively, in this study.

This investigation was overseen under the Declaration of Helsinki (2013) and approved by the Ethics Committee before the study. It also met the ethical standards for Sport and Exercise Science Research because the General data protection regulation came into force on 25 May 2018 (Regulation (EU) 2016/679).

The management of the *Fizionova* Medical Recovery Center agreed with the conduct of our research, and the collaboration was excellent bilaterally.

Subjects of the research and inclusion/exclusion criteria

All patients included in the study received approval from the specialist to participate in the kinetic recovery program.

The subjects were divided as follows: 5 patients made up the experiment group, and the other 5 made up the control group. Patients in the first group had a kinetic recovery program implemented to regain flexion degrees without the use of the TECAR therapy, and the other group of subjects benefited from the same recovery program combined with the use of the TECAR therapy performed either by passive or active movements, at the beginning or end of the recovery session. The study included ten patients, seven males, three females, aged between 24 and 44 years. The inclusion criterion was the anterior cruciate ligament revision surgery.

Recovery program

Week I

Objectives: pain control, reducing inflammation, protecting the repaired tissue, prevention of adhesions.

Methods: muscle electro stimulation, dorsal/plantar flexion, cryotherapy.

Week 2.
Objectives: pain control, reducing inflammation, maintaining the mobility of the proximal and distal joints, activation of quadriceps contraction.
Methods: mobilization of the kneecap, muscle electrostimulation, isometric contractions of the quadriceps, flexion in the hip joint, abduction + adduction from the hip joint, dorsal/plantar flexion, ventral decubitus: hip extension, cryotherapy.

Week 3.
Objectives: protecting the anterior cruciate ligament reconstruction, recovery, and maintenance of the passive flexion, prevention of quadriceps atrophy,
Methods: isometric contractions of the quadriceps, kneecap mobilization, flexion + abduction of the hip joint, passive knee flexion, dorsal/plantar flexion with isometry 10 sec, muscle electrostimulation, ventral decubitus: hip extension, knee flexion with the knee supported, ventral decubitus: stretching tips, cryotherapy feeding the articular cartilage.
Methods: isometric contractions of the quadriceps, kneecap mobilization, flexion + abduction of the hip joint, passive knee flexion, dorsal/plantar flexion with isometry 10 sec, muscle electrostimulation, ventral decubitus: hip extension, knee flexion with the knee supported, ventral decubitus: stretching the tips, cryotherapy.

Week 4.
Objectives: graft protection, improving the muscles of the affected lower limb, improving muscular endurance, active extension recovery.
Methods: kneecap mobilization, muscle electrostimulation, lateral decubitus: flexion + abduction + extension of the hip joint, ventral decubitus: extension + abduction of the hip joint with an elastic band at the ankles, ventral decubitus: stretching of the tips, dorsal decubitus: dorsiflexion with maintenance 10 sec, dorsal decubitus: pelvic lifts (bent knees) with elastic bands at the ankles, ventral decubitus: lifting on peaks (full extension), ventral decubitus: extension of the hip joint with an elastic band at the ankles, isometric contractions of the quadriceps, dorsal decubitus: pelvic lifts with bent knees and a ball between the knees, TECAR, cryotherapy.

Week 5.
Objectives: protection of the femur-kneecap joint, gradual recovery of flexion, educating the patient in graft protection.
Methods: kneecap mobilization, muscle electrostimulation, dorsal/plantar flexion with maintenance for 10 sec, flexion of the knee joint with the heel supported by the bed, dorsal decubitus: pelvic lifts, dorsiflexion flexion + abduction of the hip joint with maintenance for 10 sec, ventral decubitus: extension + abduction with elastic bands at the ankles, sitting at the edge of the bed: dorsal/plantar flexion, from orthostatic position: lifting on tiptoes at the edge of the bed, from orthostatic position: partial load affected limb, at the trellis: flexion + extension of the hip joint with elastic bands at the ankles, dynamic TECAR, cryotherapy.

Week 6.
Objectives: control of external forces, gradual recovery of flexion, reeducation of the walking scheme.
Methods: muscle electrostimulation, from orthostatic position: lifting on toes, from orthostatic position: lifting on heels, walking forward, walking backward, sitting at the edge of the bed: dorsal/plantar flexion with maintenance for 10 sec, from orthostatic position: flexion + extension of the knee joint, from orthostatic position: affected limb loading, semi squats, lifts on toes at a fixed ladder, at the fixed ladder: flexion + abduction + extension of the hip joint with maintenance, dynamic TECAR, cryotherapy.

Results

Table 1. Results of the control group

Subjects	Age	Gender	Weight	Flexion in the 2nd week postoperatively	Flexion in the 4th week postoperatively	Flexion in the 6th week postoperatively
K.L.	40	M	95 kg	25°	75°	100°
B.A.	24	F	68 kg	30°	85°	115°
O.V.	44	M	86 kg	25°	80°	105°

A.V.	30	M	73 kg	30°	80°	110°
T.R.	32	M	80 kg	20°	70°	100°

Table II. Results of the experimental group

Subjects	Age	Gender	Weight	Flexion in the 2nd week postoperatively	Flexion in the 4th week postoperatively	Flexion in the 6th week postoperatively
B.V.	41	M	77 kg	20°	89°	120°
M.S.	25	F	58 kg	30°	90°	120°
K.S.	31	M	75 kg	25°	85°	115°
R.C.	30	M	81 kg	30°	88°	115°
C.P.	38	M	78 kg	25°	85°	120°

The experimental group was also given the VAS scale, the pain scale, at the beginning of the treatment with TECAR, and at the end of it to monitor its analgesic effect and the evolution of pain in the subjects.

The VAS scale is a method for assessing pain, indicating the degree of pain according to its intensity, namely from level 10 (the most significant possible pain) to 0 (no pain).

10 - the most significant possible pain 8 - very severe pain 6—severe pain 4—moderate pain 2—low pain 0 - without pain.

According to the pain measurement scale, after treatment with the TECAR therapy, patients felt improvements at the end of the treatment compared to the beginning of the treatment.

Table III. Results at the VAS questionnaire before and after the treatment

Subjects	Age	Gender	Weight	Score VAS before the treatment	Score VAS after the treatment
B.V.	41	M	77 kg	8	2
M.S.	25	F	58 kg	6	0
K.S.	31	M	75 kg	8	0
R.C.	30	M	81 kg	8	4
C.P.	38	M	78 kg	6	2

Statistical interpretation

The statistical analysis included descriptive statistics (frequency, mean, median, standard deviation) and inferential statistics elements. The Shapiro-Wilk test was applied to determine the distribution of the analyzed data series. For comparison of means and medians, the t-Student test was applied, the parametric test was used for unpaired data, the Mann-Whitney test and Wilcoxon test, non-parametric tests, for unpaired data, respectively for paired data. The significance threshold chosen for p was 0.05. The statistical analysis was performed using the GraphPad Prism utility.

Table IV. Value of P regarding age and weight

Value of p regarding age	Experimental group	Control group	Value of p regarding weight	Experimental group	Control group
Number of values	5	5	Number of values	5	5
Minimum	25.00	24.00	Minimum	58.00	68.00
25% Percentile	27.50	27.00	25% Percentile	66.50	70.50
Median	31.00	32.00	Median	77.00	80.00
75% Percentile	39.50	42.00	75% Percentile	79.50	90.50
Maximum	41.00	44.00	Maximum	81.00	95.00
Mean	33.00	34.00	Mean	73.80	80.40

Std. Deviation	6.442	8.000	Std. Deviation	9.094	10.64
Std. Error	2.881	3.578	Std. Error	4.067	4.760
Lower 95% CI of mean	25.00	24.07	Lower 95% CI of mean	62.51	67.18
Upper 95% CI of mean	41.00	43.93	Upper 95% CI of mean	85.09	93.62
Table Analyzed		Data 1	Table Analyzed		Data 2
Column A		Experimental group	Column A		Experimental group
Vs.		Vs.	Vs.		Vs.
Column B		Control group	Column B		Control group
Unpaired t test			Mann Whitney test		
P value		0.8331	P value		0.5476

Regarding the value of p at age statistical parameters, we used the T-Student test, p> 0.05, and found out that there was no statistically significant difference between the mean ages in the two groups.

We used the Mann-Whitney test for the weight parameter, p> 0.05, and found out that there was no statistically significant difference between the two groups' mean weights.

Table V. Comparing the post operator flexion after two weeks, four weeks, and six weeks

Flexion after 2 weeks	Exper. group	Control group	Flexion after 4 weeks	Exper. group	Control group	Flexion after 6 weeks	Exper. group	Control group
Number of values	5	5	Number of values	5	5	Number of values	5	5
Minimum	20.00	20.00	Minimum	85.00	70.00	Minimum	115.0	100.0
25% Percentile	22.50	22.50	25% Percentile	85.00	72.50	25% Percentile	115.0	100.0
Median	25.00	25.00	Median	88.00	80.00	Median	120.0	105.0
75% Percentile	30.00	30.00	75% Percentile	89.50	82.50	75% Percentile	120.0	112.5
Maximum	30.00	30.00	Maximum	90.00	85.00	Maximum	120.0	115.0
Mean	26.00	26.00	Mean	87.40	78.00	Mean	118.0	106.0
Std. Deviation	4.183	4.183	Std. Deviation	2.302	5.701	Std. Deviation	2.739	6.519
Std. Error	1.871	1.871	Std. Error	1.030	2.550	Std. Error	1.225	2.915
Lower 95% CI of mean	20.81	20.81	Lower 95% CI of mean	84.54	70.92	Lower 95% CI of mean	114.6	97.91
Upper 95% CI of mean	31.19	31.19	Upper 95% CI of mean	90.26	85.08	Upper 95% CI of mean	121.4	114.1
Table Analyzed		Data 3	Table Analyzed		Data 4	Table Analyzed		Data 5
Column A		Experimental group	Column A		Experimental group	Column A		Experimental group
Vs.		Vs.	Vs.		Vs.	Vs.		Vs.
Column B		Control Group	Column B		Control group	Column B		Control group
Unpaired t test			Unpaired t test			Mann Whitney test		
P value		0.9999	P value		0.0091	P value		0.0185

For analyzing the flexion degree after two weeks of post surgery treatment, we used the T-Student test, p> 0.05. We observed no statistically significant difference between the averages of the second week postoperative flexion values in the two groups.

The second step was analyzing the flexion degree after four weeks of postoperative treatment. We used the T-Student test, p> 0.05, and observed a statistically significant difference (p=0.091) between the averages of the fourth week postoperative flexion values in the two groups.

The last step was to analyze the flexion degree after six weeks of postoperative treatment. We used the T-Student test, p <0.05, and found a statistically significant difference (p=0.0185) between the averages of the sixth postoperative week flexion values in the two groups.

Table VI. Evolution of the VAS score

VAS Score	Before treatment	After treatment
Number of values	5	5
Minimum	6.000	0.0
25% Percentile	6.000	0.0
Median	8.000	2.000
75% Percentile	8.000	3.000
Maximum	8.000	4.000
Mean	7.200	1.600
Std. Deviation	1.095	1.673
Std. Error	0.4899	0.7483
Lower 95% CI of mean	5.840	-0.4777
Upper 95% CI of mean	8.560	3.678
Table Analyzed		Data 6
Column A		Before treatment
Vs.		Vs.
Column B		After treatment
Wilcoxon signed rank test		
P value		0,0568
Exact or approximate P value?		Gaussian Approximation
P value summary		ns
Are medians signif. different? (P < 0.05)		No

Also, we needed to analyze the pain level measured with the VAS scale and to compare the values before treatment, and after treatment, so we calculated the difference using the Wilcoxon test, p> 0.05, and found out that there was no statistically significant difference (p=0.0568) between the medians of the VAS score in the two groups.

Discussions

Performance sport has become more and more physical, requiring the development of speed and strength with lots of repetition that, in time, bring injuries and deficiencies, for example in the volleyball game where many jumps, spikes, and dives are needed [11] [12], or in basketball [13].

Following the anterior cruciate ligament revision surgery, it is essential to use physiotherapy procedures associated with a recovery protocol based on therapeutic physical exercises, this leading to pain relief and recovery of early flexion due to improved mobility of the knee joint.

As in our study, Ribeiro S. et al. [14] analyzed the effects of the TECAR therapy on musculoskeletal disorders. Following the research analyzed in the literature, the results showed the beneficial effects of the TECAR therapy in many musculoskeletal disorders, as in our case, regarding the revision of the anterior cruciate ligament. Similarly to our research, Ribeiro S. et al. demonstrated that the TECAR therapy is an excellent adjuvant therapy, which should be incorporated into the rehabilitation program or used in isolation, with both short-term and long-term effects. In this study, the using the TECAR therapy allows to reduce complications related to mobility, as in the case of our study, with beneficial effects on regaining flexion and reducing pain (22.80%).

Ribeiro S., et al. [14] concluded that the TECAR therapy appears to be effective in treating musculoskeletal disorders and, at the same time, of particular importance in the rehabilitation process, perfectly incorporating into the rehabilitation program.

In the article Acute Effects of Capacitive and Resistive Electric Transfer (CRET) on the Achilles Tendon [15], Tsubasa B. et al. analyzed the effects of the TECAR therapy on the affected Achilles tendon. Following the research, the authors confirmed that following treatment with TECAR (capacitive-resistive electrical transfer) circulation in the peritendinous region significantly improved (oxy-Hb: F = 8.063, total-Hb: F = 4.564), leading to accelerated process tissue healing.

Kumaran B. and Watson T., in the article entitled "Treatment using 448k hz capacitive resistive monopolar radiofrequency improves pain and function in patients with osteoarthritis of the knee joint: a randomized controlled trial" [16], analyzed knee function and pain following TECAR therapy. As in our study, the pain measured via the VAS scale, improved considerably in the experimental group compared to the control group. Furthermore, there were considerable differences in the post-treatment experiment group's case in terms of knee function, a fact demonstrated in our study. (Mean difference: 1.3 (95 % CI: 0.02 to 2.6), size of effect: 0.94)

Also, Carlo A. Coccetta et al. showed that this diathermy therapy significantly improved endurance, physical function, and knee pain. Following the study, the authors revealed that the capacitive and resistive electrical transfer therapy could reduce pain, stiffness, and functional limitation in the knee [17].

Clijsen R. et al., in "Does the application of TECAR therapy affect temperature and perfusion of skin and muscle microcirculation? a pilot feasibility study on healthy subjects" [18], described the effects of the TECAR therapy on microcirculation and intramuscular blood flow. (Intramuscular Blood Flow% before and after treatment: placebo 0.05–1.1, capacitive -0.09–1.9, resistive: 2.06 - 3.3). Following the research, both the capacitive and resistive TECAR therapy applied to the subjects induced major changes compared to the placebo effect, applied to another group of subjects. (skin temperatureº: placebo: -2.3–1.5, capacitive: 0.9–1.3, resistive: 2.8 - 2).

Another research that treated the effects of the TECAR therapy [8] is that of Notarnicola A., et al., who compared the effects of the TECAR therapy effects on low back pain compared to laser therapy. Following the study, the authors showed significant differences in favor of the TECAR therapy, with significantly superior results compared to laser therapy.

In the article "Does transfer capacitive, resistive energy has a therapeutic effect on Peyronie's disease? Randomized single-blind, sham-controlled study on 96 patients: fast pain relief [19], Pavone C., and colleagues observed a significant reduction in pain at the end of the treatment (79.6%), showing, as in the case of our research, the importance of using physiotherapy and electrotherapy procedures on the rehabilitation process.

Conclusions

The hypothesis of the study was confirmed. The patients, who benefited in the first six weeks from a personalized recovery program, developed by us, combined with TECAR therapy, performed both statically and dynamically, reached optimal flexion rates faster than patients who only benefited from the kinetic recovery program.

The post-revision recovery protocol of the anterior cruciate ligament based on therapeutic physical exercises is more effectively combined with electrotherapy.

The TECAR therapy has an analgesic effect and a myorelaxant and tissue healing accelerator effect, allowing the patient to advance in the recovery and rehabilitation process.

Following surgery, the immediate postoperative recovery is of considerable importance for the lost function (degrees of mobility regaining much more difficult in cases of prolonged immobilization and lack of movement).

Combining the recovery protocol based on therapeutic physical exercises with the TECAR therapy has beneficial effects on rehabilitating the lost function with a cryotherapy procedure.

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