

## EFFECT OF THE COMBINED UTILIZATION OF STATIC PROGRESSIVE STRETCHING AND PHONOPHORESIS WITH HYDROCORTISONE IN REHABILITATION OF KNEE CONTRACTURES CAUSED BY ARTHROFIBROSIS

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Arthrofibrosis is the abnormal proliferation of fibrous tissue in a joint with an unclear etio-pathogenesis that leads to loss of motion, pain, muscle weakness, swelling, and functional limitation. In the knee, arthrofibrosis may present as a localized form (cyclops lesion, infrapatellar contracture syndrome, patellar clunk syndrome, localized intra-articular scarring) or as a generalized stiffness. Initial treatment for arthrofibrosis is aggressive therapy: arthroscopic debridement combined with manipulation under anesthesia (MUA) is preferred after 6 weeks of failed conservative treatment [5]. A comprehensive arthroscopic arthrolysis and careful postoperative rehabilitation are the hallmarks for successful outcomes [2].

Arthrofibrosis is a frequent complication in patients with anterior cruciate ligament (ACL) reconstruction followed with unsuccessful rehabilitation. Although prevention is the best treatment, little information exists within the literature regarding the management and rehabilitative intervention for arthrofibrosis [1].

Shelbourne et al classified different types of arthrofibrosis in the knee based on the loss of knee extension, flexion, or both; the location of scar tissue formation intra-articularly; and the mobility and location of the patella (Table 1) [10]. However, once arthrofibrosis has occurred, the treatment approach widely varies. Numerous published surgical reports exist regarding the cause and treatment of arthrofibrosis, but the rehabilitation programs are poorly defined [3,11].

Range of motion (ROM) loss is one of the most serious sequelae of fractures, soft tissue injuries around the knee and knee surgeries. Pyogenic infection, prolonged postoperative immobilization of the knee, and improper rehabilitation can result in a ROM deficit, however soft tissue damage and adhesions around the knee after a distal femoral fracture are responsible in most cases. In the past, open surgery (quadricepsplasty) was performed frequently for arthrofibrosis of intraarticular or extraarticular origin, however, it is a high-risk procedure that requires lengthy rehabilitation and postoperative immobilization [4].

The goal of the current study was to establish the superiority of the effect of the combined utilization of static progressive stretching and hydrocortisone phonophoresis over standard therapeutic exercise programs for the rehabilitation process of knee contractures caused by arthrofibrosis.

To achieve this goal the following objectives were set:

1. The selection of patients with type III or IV arthrofibrosis (according to the Shelbourne classification) following a lengthy immobilization or surgical treatment of the knee (after 3-4 months) with significant limitations of flexion as well as extension [10].
2. The random division of patients into two groups: I – experimental group and II – control group.
3. The assessment of ROM (range of motion) of the knee prior to the study and after a 2-week of rehabilitation program.
4. Planning and implementation of 10 procedures of phonophoresis with hydrocortisone before the inception of the rehabilitation program in the experimental group [8].
5. Providing both groups with 2-week long rehabilitation programs with static progressive stretching home exercise programs.
6. Statistical processing and analysis of the results.

**Material and methods.** 29 patients between ages of 18 and 60 (mean age 42±4.3) participated in the prospective randomized controlled study, 19 (65%) male and 10 (35%) female with clinical signs of type III and IV contracture of the knee, extension limitation >10° and flexion deficit >25° when compared to the uninjured side. A minimum of 3 months had passed since the initial injury or the surgical intervention in all cases. 10 male and 5 female patients were randomly distributed to Group I (experimental group) while 9 male and 5 female patients were distributed into Group II (control group) accordingly.

The patients' cases that were part of this study were divided into three groups according to the causes of arthrofibrosis: 12 cases of arthrofibrosis following ligament lesions, 11 cases following fractures in the knee area and 6 cases after meniscus damage or any other causes. It is also

*Table 1. Classification of Arthrofibrosis (Shelbourne et al)*

| TYPE   | EXTENSION           | FLEXION           | PATELLAR MOBILITY            |
|--------|---------------------|-------------------|------------------------------|
| Type 1 | <10° extension loss | Normal flexion    | Normal                       |
| Type 2 | >10° extension loss | Normal flexion    | Normal                       |
| Type 3 | >10° extension loss | >25° flexion loss | Decreased                    |
| Type 4 | >10° extension loss | >30° flexion loss | Decreased and patella infera |

Table 2. The causes of knee arthrofibrosis

| Case characteristic              | n  | III | IV | Female | Male |
|----------------------------------|----|-----|----|--------|------|
| Ligament damage                  | 12 | 10  | 2  | 2      | 10   |
| Fracture in the knee area        | 11 | 6   | 5  | 5      | 6    |
| Meniscus damage and other causes | 6  | 4   | 2  | 3      | 3    |
| Total                            | 29 | 20  | 9  | 10     | 19   |

Table 3. The initial data for knee ROM according to the types of arthrofibrosis

| Group            | n  | Extension<br>III Deficit IV |                   | Flexion<br>III Deficit IV |                 |
|------------------|----|-----------------------------|-------------------|---------------------------|-----------------|
|                  |    | n=20<br>(>10°)              | n=9               | (>25°) n=20               | (>30°) n=9      |
| I - Experimental | 15 | 14.8±2.4<br>(n=10)          | 15.3±3.1<br>(n=5) | 27±2.2<br>(n=10)          | 48±4.7<br>(n=5) |
| II - Control     | 14 | 12.5±3.1<br>(n=10)          | 13.7±1.4<br>(n=4) | 28±2.3<br>(n=10)          | 50±3.9<br>(n=4) |

worth noting that out of the 9 cases of type IV contractures 5 were associated with fractures in the knee joint, 2 with ligament damage and 2 with meniscus damage while in the cases of type III contractures – 10 were associated with ligament damage, 6 with fractures in the knee area and 4 with meniscus damage (Table 2).

Table 3 demonstrates the distribution of cases and patients according to the type of arthrofibrosis and the initial data for the limitation of movement in the knee.

15 patients were distributed into Group I who had extension limitations with type III arthrofibrosis and the average deficit of 14.8±2.4 as well as with type IV arthrofibrosis and the average deficit of 15.3±3.1. At the same time, the average flexion deficit in this same group was 27±2.2 with type III arthrofibrosis and 48±4.7 in the cases of type IV. Group II consisted of 14 patients with knee extension deficit averages of 12.5±3.1 and 13.7±1.4 with type III and IV arthrofibrosis accordingly. The data averages concerning the limitation of knee flexion in Group II were as follows: 28±2.3 with type III arthrofibrosis and 50±3.9 with type IV.

The patients in Group I underwent 10\*10-minute procedures of phonophoresis with highly concentrated hydrocortisone (10%), alongside a high intensity ultrasound (1.0 Wt./cm<sup>2</sup>) with 1.0 Mhz frequency and 50% duty cycle during 2 weeks prior to the start of the rehabilitation program [7-9]. After 2 weeks, both groups received the same rehabilitation program that consisted of typical home exercise programs and static progressive stretching procedures for the following 10 days in an ambulatory setting.

The program for static progressive stretching (SPS) was conducted in the Sports Medicine and Rehabilitation Clinical Center of TSMU (Tbilisi State Medical University) 5 times per week, during 30 minutes using a special

static stretching device (DeRoyal Static-Pro Progressive Knee Splint, USA and NeeHab LLC Flexor and Extensor Device, USA) for 6 5-minute series with a gradual increase in knee flexion or extension. The intensity of the mechanical effect was controlled monitored using the “Stretching Intensity Scale” and with absence of pain – 2, 3 points (Fig. 1).

“Stretching Intensity Scale”

0 1 2 3 4 5 6 7 8 9 10  
Severe pain should not be present during an adequate stretching!

Fig. 1. Stretching Intensity Scale

At the initial stage of the rehabilitation program, the main focus was to decrease and eradicate the extension deficit in the knee joint.

In case of severe pain after the exercise, ice applications were used for 15-20 minutes. Passive range of motion (PROM) in the injured knee was measured in degrees with a goniometer before and after the intervention.

The statistical analysis of the results was conducted via AcaStat Software’s StatCalc calculator. The comparison of the data and the reliability of the differences between them were assessed using the t-student criteria.

**Results and discussion.** The results of the aforementioned research have clearly shown improvement of ROM with regards to both extension as well as flexion of the knee in both groups, however, within Group I, which included highly concentrated hydrocortisone phonophoresis alongside with static progressive stretching and home exercise program (UPH+SPS+HEP), the difference in passive flexion and extension of the knee before and after the end of the rehabilitation program was significant and reli-

able ( $p < 0.05$ ) in all cases (Table 4), as opposed to Group II, where static progressive stretching was performed solely alongside a home exercise program (SPS+HEP),

which demonstrated insignificant differences ( $p > 0.05$ ) among the same parameters during all 4 instances of measurements according to the t-student criteria (Table 5).

Table 4. Initial and final data of PROM deficits in Group I

| Group I (n=15)      | Initial Deficit |          |         |        | UPH*+SPS**+HEP*** |         |         |         |
|---------------------|-----------------|----------|---------|--------|-------------------|---------|---------|---------|
|                     | Extension       |          | Flexion |        | Extension         |         | Flexion |         |
| Arthrofibrosis type | III             | IV       | III     | IV     | III               | IV      | III     | IV      |
| ROM                 | 14.8±2.4        | 15.3±3.1 | 27±2.2  | 48±4.7 | 0±0.5             | 2.0±0.7 | 5±1.7   | 12±2.8  |
| P                   |                 |          |         |        | P=0.001           | P=0.004 | P=0.001 | P=0.001 |

\*UPH - UltraPhonophoresis; SPS\*\* - Static Progressive Stretching; HEP\*\*\* - Home Exercise Program;

Table 5. Initial and final data of PROM deficits in Group II

| Group II (n=14)     | Initial Deficit |          |         |        | SPS+HEP   |         |         |        |
|---------------------|-----------------|----------|---------|--------|-----------|---------|---------|--------|
|                     | Extension       |          | Flexion |        | Extension |         | Flexion |        |
| Arthrofibrosis type | III             | IV       | III     | IV     | III       | IV      | III     | IV     |
| ROM                 | 12.5±3.1        | 13.7±1.4 | 28±2.3  | 50±3.9 | 9.7±2.3   | 7.2±2.1 | 22±2.4  | 41±2.3 |
| P                   |                 |          |         |        | P=0.095   | P=0.153 | P=0.68  | P=0.93 |

Table 6. The difference of the initial and final data between the experimental and control groups

| Arthrofibrosis type | PROM       | I          | II         | Difference |
|---------------------|------------|------------|------------|------------|
| III<br>n=20         | Ext.       | degree (°) | degree (°) |            |
|                     | Initial    | 14.8       | 12.5       | 2.3        |
|                     | Final      | 0          | 9.7        |            |
|                     | Difference | 14.8       | 2.8        | 12         |
|                     | P          | <0.001     | <0.095     |            |
|                     | %          | 100        | 22.4       |            |
|                     | Flex.      |            |            |            |
|                     | Initial    | 27.0       | 28.1       | 5.1        |
|                     | Final      | 5.0        | 22.5       |            |
|                     | Difference | 22.0       | 5.6        | 16.4       |
|                     | P          | <0.004     | <0.15      |            |
| %                   | 81.5       | 19.9       |            |            |
| IV<br>n=9           | Ext.       |            |            |            |
|                     | Initial    | 15.3       | 13.7       | 1.4        |
|                     | Final      | 2.0        | 10.0       |            |
|                     | Difference | 13.1       | 3.7        | 9.4        |
|                     | P          | <0.001     | <0.68      |            |
|                     | %          | 86         | 27         |            |
|                     | Flex.      |            |            |            |
|                     | Initial    | 48.47      | 50.8       | 2.33       |
|                     | Final      | 12.0       | 41.2       |            |
|                     | Difference | 36.47      | 9.6        | 26.87      |
|                     | P          | <0.001     | <0.93      |            |
| %                   | 75         | 18.8       |            |            |

If we merge the data concerning the initial and final knee ROM from both groups into a single table and express the differences between them in absolute values and percentages, it will be clear that extension PROM deficit in patients with type III arthrofibrosis in Group I has decreased by 14.8 (100%) while in patients with type IV arthrofibrosis it decreased by 13.1 (86%). On the other hand, the extension deficit in patients with type III arthrofibrosis from Group II decreased by 2.8 (22%) and in patients with type IV arthrofibrosis by 3.7 (27%). As for flexion deficits, the data showed the following results: In group I flexion deficit decreased by 22 (81.5%) in patients with type III and by 36.47 (75%) in patients with type IV. At the same time, the flexion deficit reduction in Group II was 5.6 (19.9%) and 9.6° (18.8%) in patients with type III and IV arthrofibrosis respectively.

These conclusive results have shown that the effect of static progressive stretching alongside with the adequate home exercise program can be enhanced by the additional utilization of phonophoresis with highly concentrated hydrocortisone (10%) prior to the inception of the aforementioned standard therapeutic exercise program. The most significant and reliable advantage of this approach is visible within patients with type III arthrofibrosis where a 10-day treatment course could possibly result in a 80-100% improvement with regards to knee ROM. As for patients with type IV arthrofibrosis, the improvement of ROM reached approximately 40% (Table 6).

If we express the initial and final data of the patients with type III and IV arthrofibrosis from both groups graphically, the advantage of utilizing ultraphonophoresis with hydrocortisone before the start of static progressive stretching and home exercise programs, when compared to the solitary use of therapeutic exercises (SPS and HEP) with regards to efficacy, it is clear and unambiguous (Fig. 2).

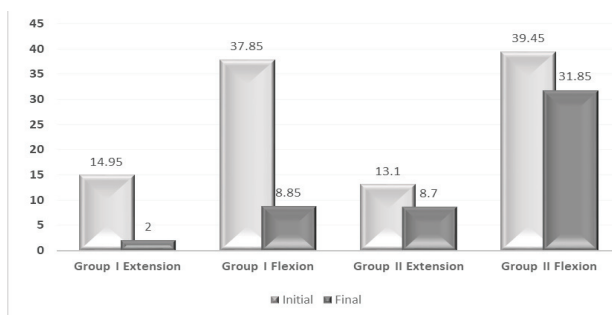


Fig. 2. Total change dynamics in initial and final ROM mean data of both groups

The cause for the abovementioned advantage is most likely due to the disruptive effect of ultrasound on fibrous tissue formation as well as the weakening of firmness of the already present scar tissue from the impact of penetration by highly concentrated hydrocortisone which in turn enables the improvement of knee ROM with mechanical stretching procedures [6]. Obviously, these effects would

have been more apparent and significant during earlier stages of scar tissue formation which takes place soon after the initial injury or surgical intervention when the first signs of contractures arise, however, mechanical stretching at this stage of recovery is unacceptable as it hinders the regeneration-reparation processes of damaged tissues and creates the risk of causing additional damage.

**Conclusion.** The effect of static progressive stretching in the rehabilitation process of knee contractures caused by arthrofibrosis is greatly improved after the utilization of ultraphonophoresis with highly concentrated hydrocortisone alongside with standard home exercise programs and this effect is especially apparent in the cases of patients with type III arthrofibrosis and knee flexion contractures.

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## SUMMARY

### EFFECT OF THE COMBINED UTILIZATION OF STATIC PROGRESSIVE STRETCHING AND PHONOPHORESIS WITH HYDROCORTISONE IN REHABILITATION OF KNEE CONTRACTURES CAUSED BY ARTHROFIBROSIS

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Arthrofibrosis is the abnormal proliferation of fibrous tissue in a joint with an unclear etiopathogenesis that leads to loss of motion, pain, muscle weakness, swelling, and functional limitation. Various methods of therapy are utilized to treat the aforementioned pathology and among them are also aggressive approaches such as static progressive stretching.

The goal of the current study was to establish the superiority of the effect of the combined utilization of static progressive stretching and hydrocortisone phonophoresis over standard therapeutic exercise programs for the rehabilitation process of knee contractures caused by arthrofibrosis.

29 patients between the ages of 18 and 60 (mean age 42±4.3 y.o.) participated in the prospective randomized controlled study, 19 male (65%) and 10 female (35%) with clinical signs of type III and IV contracture of the knee, extension limitation >10° and flexion deficit >25° when compared to the uninjured side. A minimum of 3 months had passed since the initial injury or the surgical intervention in all cases. 10 male and 5 female patients were randomly distributed to Group I (experimental group) while 9 male and 5 female patients were distributed into Group II (control group) accordingly.

The patients from Group I underwent a 2-week long treatment course (10 procedures) with highly concentrated (10%) hydrocortisone phonophoresis before the inception of the standard rehabilitation program while the patients from Group II went through a rehabilitation course consisting solely of static progressive stretching and a home exercise program.

The effect of static progressive stretching in the rehabilitation process of knee contractures caused by arthrofibrosis is greatly improved after the utilization of ultraphonophoresis with highly concentrated hydrocortisone alongside standard home exercise programs and this effect is especially apparent in the cases of patients with type III arthrofibrosis and knee flexion contractures.

**Keywords:** Artrophybrosis; Ultraphonophoresis; SPS – Static Progressive Stretching; MUA- Manipulation under anesthesia; HEP- Home Exercise Program;

## РЕЗЮМЕ

### ЭФФЕКТ КОМБИНИРОВАННОГО ИСПОЛЬЗОВАНИЯ СТАТИЧЕСКОГО ПРОГРЕССИРУЮЩЕГО РАСТЯЖЕНИЯ И ФОНОФОРЕЗА С ГИДРОКОРТИЗОНОМ В ПРОЦЕССЕ РЕАБИЛИТАЦИИ КОНТРАКТУР КОЛЕННОГО СУСТАВА, ВЫЗВАННЫХ АРТРОФИБРОЗОМ

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Артрофиброз является аномальной пролиферацией фиброзной ткани в суставе с неясным этиопатогенезом, который приводит к потере движения, боли, мышечной слабости, отекам и функциональным ограничениям. Для лечения вышеупомянутой патологии используются различные способы терапии, среди них также агрессивные подходы, такие как статическое прогрессирующее растяжение.

Целью настоящего исследования явилось установить превосходство эффекта комбинированного использования статического прогрессирующего растяжения и фонофореза гидрокортизоном над стандартными программами лечебных упражнений для процесса реабилитации контрактур коленного сустава, вызванных артрофиброзом.

29 пациентов в возрасте от 18 до 60 лет (средний возраст 42±4,3 г.) участвовали в проспективном рандомизированном контролируемом исследовании, среди них 19 (65%) мужчин и 10 (35%) женщин с клиническими признаками контрактуры колена III и IV типа, ограничением разгибания >10° и дефицитом сгибания >25° в сравнении со здоровой стороной. Во всех случаях как минимум 3 месяца прошло с момента первоначальной травмы или хирургического вмешательства. 10 пациентов мужского пола и 5 пациентов женского пола случайным образом распределены в I группу (экспериментальная), 9 пациентов мужского пола и 5 пациентов женского пола - во II группу (контрольная).

Пациенты из I группы проходили курс лечения продолжительностью 2 недели (10 процедур) с использованием фонофореза гидрокортизоном высокой концентрации (10%) до начала стандартной программы реабилитации, а пациенты из II группы проходили курс реабилитации, состоящий исключительно из статического прогрессирующего растяжения и про-

граммы упражнений на дому. Эффект статического прогрессирующего растяжения в процессе реабилитации контрактур коленного сустава, вызванных артрофиброзом, значительно улучшается после использования ультрафонофореза с высококонцентрированным гидрокортизоном, наряду со стандартными программами упражнений на дому, и этот эффект особенно очевиден в случаях пациентов с артрофиброзом III типа и контрактурами сгибания колена.

## რეზიუმე

სტატიკური პროგრესირებადი დაჭიმვებისა და ჰიდროკორტიზონით ფონოფორეზის კომბინირებული გამოყენების ეფექტი მუხლის ართროფიბროზით გამოწვეული კონტრაქტურების რეაბილიტაციაში

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ართროფიბროზი არის სახსარში ფიბროზული ქსოვილის გაძლიერებული პროლიფერაცია, რომლის განვითარების მექანიზმი ბოლომდე ცნობილი არ არის და იგი იწვევს მოძრაობის გაძნელებას სახსარში, ტკივილს, კუნთების სისუსტეს, შეშუპებას და ფუნქციის შეზღუდვას. აღნიშნული მდგომარეობის მკურნალობისათვის გამოიყენება სხვადასხვა ტიპის, მათ შორის, ისეთი აგრესიული ფიზიკური თერაპიის მეთოდები, როგორიცაა სტატიკური პროგრესირებადი დაჭიმვები.

კვლევის მიზნის წარმოადგენდა მუხლის არ-

თროფიბროზით გამოწვეული კონტრაქტურების რეაბილიტაციაში სტატიკური პროგრესირებადი დაჭიმვებისა და ჰიდროკორტიზონით ფონოფორეზის კომბინირებული მოქმედების უპირატესი ეფექტის დადგენა სტანდარტული სამკურნალო სავარჯიშო პროგრამის იზოლირებულად გამოყენებასთან შედარებით.

რანდომიზებულ კონტროლირებად პროსპექტულ კვლევაში მონაწილეობდა 18-დან 60 წლამდე 29 პაციენტი (საშუალო ასაკი  $42 \pm 4,3$  წ.), აქედან 19 (65%) მამაკაცი და 10 (35%) ქალი მუხლის სახსრის III და IV ტიპის კონტრაქტურის კლინიკური ნიშნებით, მუხლის გაშლის შეზღუდვით  $>10^\circ$  და მუხლის მოხრის დეფიციტით  $>25^\circ$  ჯანმრთელ მხარესთან შედარებით. ყველა შემთხვევაში დაზიანებიდან ან ქირურგიული ჩარევიდან გასული იყო მინიმუმ 3 თვე. I (ძირითად) ჯგუფში რანდომულად განაწილდა 10 მამაკაცი და 5 ქალი, II (საკონტროლო) ჯგუფში – 9 მამაკაცი და 5 ქალი.

I ძირითადი ჯგუფის პაციენტებს სარეაბილიტაციო პროგრამის დაწყების წინ ჩატარდა ფონოფორეზის 10 პროცედურა (2 კვირის განმავლობაში) მაღალი კონცენტრაციის (10%) ჰიდროკორტიზონის გამოყენებით, ხოლო II (საკონტროლო) ჯგუფის პაციენტებთან განხორციელდა სტატიკური პროგრესირებადი დაჭიმვებისა და დამოუკიდებელი ვარჯიშებისგან შემდგარი სარეაბილიტაციო პროგრამა.

სტატიკური პროგრესირებადი დაჭიმვების ეფექტი მუხლის ართროფიბროზით გამოწვეული კონტრაქტურების რეაბილიტაციის პროცესში მნიშვნელოვნად ძლიერდება მაღალი კონცენტრაციის ჰიდროკორტიზონით ულტრაფონოფორეზის გამოყენების შემდგომ, დამოუკიდებელი სამკურნალო ვარჯიშების ფონზე, განსაკუთრებით III ტიპის ართროფიბროზის და მუხლის მოხრითი კონტრაქტურების რეაბილიტაციის შემთხვევებში.