

Peculiarities of physical therapy for athletes having arthrofibrosis after primary and revision anterior cruciate ligament reconstruction

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Abstract:

Purpose: The aim of the article is to analyze efficiency of physical therapy in terms of range of motions augmentation in knee joints of athletes having knee-joint arthrofibrosis that has evolved after primary and revision anterior cruciate ligament reconstruction as well as ability for adequate, full-fledged, and consistent physical therapy prevention of surgical treatment of arthrofibrosis with athletes after primary or revision anterior cruciate ligament reconstruction.

Material: We have analyzed and assessed results of physical therapy with sixteen patients diagnosed with knee-joint arthrofibrosis that evolved after primary anterior cruciate ligament reconstruction, and with eight patients that suffered from arthrofibrosis after revision anterior cruciate ligament reconstruction. These patients included twelve men and twelve women. Average age was 36 years (from 18 to 54). Average term after the operation at the moment of augmentation was 5,4±4,6 months.

Results: The author has analyzed results of physical therapy with twenty-four patients having knee-joint arthrofibrosis after anterior cruciate ligament reconstruction (sixteen patients after primary anterior cruciate ligament reconstruction and eight patients after revision anterior cruciate ligament reconstruction). All patients underwent series of measurements of range of motions in dynamics in order to assess the effect of conservative treatment; radiography of cruciate ligament in two projections to define the height of knee cap placement; MRT of cruciate ligament. The level of patients' activity was defined by Tegner and Lysholm's scales.

Conclusions: Arthrofibrosis is easier to prevent rather than treat. That is why it is extremely important to reach maximum range of motions before the operation with the help of physical therapy, and restore muscles strength and function, especially of the knee joint extension apparatus.

Key words: physical therapy, athletes, knee-joint arthrofibrosis, primary and revision anterior cruciate ligament reconstruction.

Introduction

Use of arthroscopic hi-tech operations on lower limbs joints, namely reconstruction of anterior cruciate ligament, enables relatively fast rehabilitation. Moreover, some patients cannot restore full-value motions in knee joints after an operation due to development of arthrofibrosis (DeHaven KE et al, 2003; Wasilewski SA et al, 1993). Arthrofibrosis is characterized by excessive development of fibrosis tissue directly in knee joint structures and in periarticular tissues, pain syndrome, limited motions, muscles weakness, toughness of motions, and functional limitations of various degrees. The issue of treatment, especially prevention of the development of arthrofibrosis, is related to insufficient experience of surgeons and physical therapists in this pathology. Respectfully, they cannot give timely diagnosis, which postpones rational treatment and creates the need in additional operations (Shelbourne KD et al, 1991). Early medical rehabilitation and physical therapy play important role in prevention of arthrofibrosis (Erickson Brandon J. et al, 2017).

One of the important urgent issues of rehabilitation after anterior cruciate ligament reconstruction is the issue of optimal terms of athlete's rehabilitation after revision anterior cruciate ligament reconstruction (Erickson Brandon J. et al, 2017). Optimal term of rehabilitation is stipulated by the kind of sport, level of athlete's preparedness to the operation, level of functional ability after the operation, the degree of muscles hypotrophy, level of neuromuscular control after the operation, quality of operation, type of transplant fixation, type of transplant, number and localization of personal tendons samplings for anterior cruciate ligament reconstruction. However, the second to quality of operation factor that impacts athlete's rehabilitation is quality of rehabilitation process and physical therapy.

Rehabilitation of anterior cruciate ligament is widely used around the world. Thus, in the USA, 60-75 thousand anterior cruciate ligament reconstructions are done annually. At the same time, the number of operations could be bigger if it were not for a number of factors (Johnson DL HC, Maday MG, Fu FH, et al, 1994). However, despite high efficiency of these surgeries, 3 to 10 thousand revision anterior cruciate ligament reconstructions are done in the USA annually (Noyes FR, Barber-Westin SD, 2001). This number does not cover all needs in revision reconstructions. Fraction of anterior cruciate ligament reconstructions, therefore the number of revision anterior cruciate ligament reconstructions, increases every year as athletes go on competing on professional and amateur levels; the number of older athletes grows and, respectfully, the demands to the stability of knee joints grow (Uribe JW et al, 1996; Salata MJ WE, 2010). It may be hard to evaluate whether patient's sensations are related to drawbacks or complications after anterior cruciate ligament reconstruction or these are subjective sensations, which does not reflect the actual state. The range of flexing knee joints is not the only criteria for arthrofibrosis as sufficient range for everyday purposes can become an obstacle for returning to professional sports.

Recovery of athletes after anterior cruciate ligament reconstruction to previous level (prior the injury) is not always successful. In case of revision anterior cruciate ligament reconstruction, chances for a full rehabilitation are even slimmer. However, adequate surgical technique and physical therapy before and after the operation allow increase percentage of athletes who return to sports in general, and athletes, who return to professional sports on the level prior to operation. Tight correlation between a surgeon and physical therapist is extremely important (Uribe JW et al, 1996; Salata MJ WE, 2010).

Understanding the reason of unsatisfactory results of primary or revision anterior cruciate ligament reconstruction stipulates further treatment process. Usually, patients have complaints that can be divided into four basic groups: limited range of motions, knee joint flexing apparatus disorder, knee joint chronic or recurring instability, and pain related to arthrosis, complex regional pain syndrome and other complaints. By means of surgery (revision anterior cruciate ligament reconstruction) only instability of knee joint can be corrected, though not always as in some cases this instability is related not to loss or inferior restoration of primary passive stabilizer – anterior cruciate ligament, but also related to injuries of such secondary stabilizers as menisci. Another reason for instability that cannot be influenced surgically is loss of strength and dysfunction of active knee-joint stabilizers (muscles), and dysfunction of proprioception through loss of anterior cruciate ligament as an important organ that provides not only stability but also proprioception, and through inability to restore proprioception surgically. In some cases, namely in cases of arthrofibrosis, or cyclopes syndrome, surgical treatment can be reasonable with patients complaining on limited motions in knee joint. At the same time, physical therapy is to be done for patients with all types of complaints; in case of limited motions in knee joint (especially with arthrofibrosis), dysfunction of flexing apparatus and arthrosis it is crucial.

The most frequent complaint after primary anterior cruciate ligament reconstruction after the pain abates is limited range of motions. The reasons for it can be various: arthrofibrosis, contracture caused by continued immobilization, complex regional pain syndrome, errors in anterior cruciate ligament reconstruction (impingement due to insufficient removal of anterior cruciate ligament stump, due to cyclopes syndrome, inaccurate channels etc). The most difficult form for treatment of limited range of motions, which is common at injuries of anterior cruciate ligament, is arthrofibrosis. Although, arthrolysis and other surgical interferences aimed at augmentation of range of motions must be done in some cases, physical therapy is the basis of treatment process.

Despite topicality of the issue, scientific references lack information regarding ability for rehabilitation of athletes having arthrofibrosis after primary and revision reconstruction and for arthrofibrosis therapy with the help of physical therapy. The results of physical therapy with athletes having arthrofibrosis that evolved after primary or revision anterior cruciate ligament reconstruction can be different from general results due to greater motivation of athletes, them being better disciplined regarding quality and regularity of exercising as well as due to bigger tolerance to pain, which is often an integral component of arthrofibrosis physical therapy.

Objective of the study to carry out the analysis efficiency of physical therapy in terms of range of motions augmentation in knee joints of athletes having knee-joint arthrofibrosis that has evolved after primary and revision anterior cruciate ligament reconstruction as well as ability for adequate, full-fledged, and consistent physical therapy prevention of surgical treatment of arthrofibrosis with athletes after primary or revision anterior cruciate ligament reconstruction.

Material & methods

We have analyzed and assessed results of physical therapy with sixteen patients diagnosed with knee-joint arthrofibrosis that evolved after primary anterior cruciate ligament reconstruction, and with eight patients that were tormented from arthrofibrosis after revision anterior cruciate ligament reconstruction. These patients included twelve men and twelve women. Average age was 36 years (from 18 to 54). Average term after the operation at the moment of augmentation was 5,4±4,6 months.

All patients had series of range of motions measurement in dynamics in order to assess the effect of conservative treatment; radiography of knee joint in two projections to define the height of knee cap placement;

MRT of knee joint using Siemens MAGNETOM Avanto 1,5 T in order to reveal knee joint hard block that would require surgical procedure, to conduct differential diagnostics of weakness of quadriceps femoris with mechanical hindrance of normal knee cap's motion, to exclude complex regional type-1 pain syndrome, hermarthrosis, synovitis as well as infection process in case of available local hypothermia typical to early stages of arthrofibrosis. The level of patients' activity has been assessed by Tegner and Lysholm scales (Tegner Y, Lysholm J., 1985; Hambly, Karen, 2010).

The results have been assessed by the dynamics and deficit of knee joint flexing in 8 to 12 weeks of physical therapy by Tegner and Lysholm scales in 12 months after primary or revision anterior cruciate ligament reconstruction. A normal level was not defined as range of motions in counter-lateral limb, but as knee joint flexing range in $0^{\circ}/0^{\circ}/120^{\circ}$ as anterior cruciate ligament transplant can limit knee joint flexing to over 120° with some patients.

All patients had series of range of motions measurement in dynamics in order to assess the effect of conservative treatment; radiography of knee joint in two projections to define the height of knee cap placement; MRT of knee joint. No progress throughout 2 weeks at any stage of physical therapy was the criteria for arthroscopic surgical treatment (arthrolysis).

Exclusion criteria while selecting patients for physical therapy were available features of cyclopes syndrome or knee joint hard block caused by meniscus tear or transplant of anterior cruciate ligament that called for surgical procedure prior to physical therapy as well as active inflammation process in knee joint at the moment of consulting the doctor. Damage of anterior cruciate ligament transplant without knee joint hard block was not an exclusion criterion as, in any case, it called for physical therapy, reaching sufficient range of motions, and strengthening of operated limbs muscles prior to surgical procedure.

The course of arthrofibrosis is often complicated by distal migration (low placement) of knee cap – patella infera. In order to assess the height of knee cap placement, the aforementioned radiography has been used. At the same time, *Insall-Salvati* index (relation of knee cap length from knee cap's lower pole to uneven surface of shinbone to height or length of knee cap, usually $1,02 \pm 0,2$, index lower than 0.8 is considered to be patella infera) and *Blackburne-Peel* index (relation of distance from lower part of knee cap cartilage to plateau level of shinbone to length of knee joint cap surface, usually 0,54-1,06, index lower than 0.54 is considered to be patella infera) have been used (fig. 1).

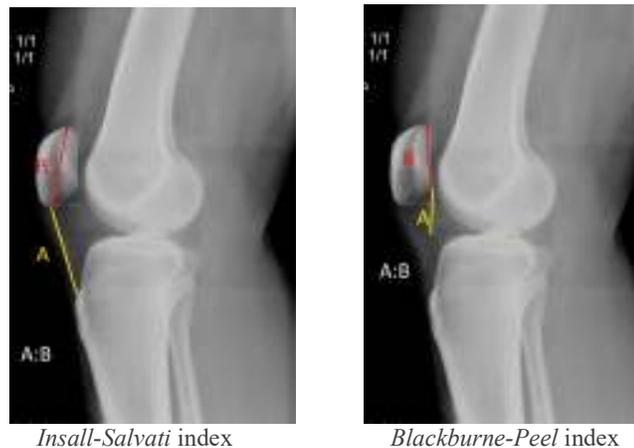


Fig. 1. Defining *Insall-Salvati* and *Blackburne-Peel* indices by radiographs

Also, index of knee cap placement height and counter-lateral healthy knee joint have been compared. Low placement of knee cap, strengthening of quadriceps femoris, stretching of knee cap ligament, and mobilization of knee cap have been focused on. Often, they were conducted for some time prior to flexing in order to prevent excessive load on knee joint cartilage and its damaging while working out.

Physical therapy has been conducted by the program developed by us. The program of physical therapy included the following elements:

1. Manual passive mobilization of knee cap by a physical therapist in four directions: proximally, distally, laterally, medially in position of the joint full extension and at full relaxation of thigh quadriceps femoris.
2. Working out flexing range to full extension of knee joint (0°) with the help of extension exercises with hyper-pressing (a eight is applied to extended knee joint, the weight is being gradually increased; the lowest weight is selected, with the help of which a 3° extension can be reached in 3 days) (fig. 2). Fter these, bending exercises are done. At the same time, should be exercised mobilization is to be done in order to prevent paunches and reduce hyper-pressing in knee-joint and thigh segment.

3. Working out flexing range to full bend (bending to 120° at available hard hindrance to further bending was considered to be a good result) with hyper-pressing is done by physical therapist manually or with the help of a towel (can be done by the patient independently) for 5 minutes ever 30 minutes.



Fig. 2. Extension exercises with hyper-pressing

4. Working out active and passive rotation motions in knee joint with bending at 90°.
5. Eccentric contractions of quadriceps femoris during exercises with closed kinematic chain (negative-phase squats).
6. Squats using personal and subsidiary weight, exercising on gym apparatuses with closed kinematic chain.
7. Achilles tendon stretching.
8. Quadriceps femoris stretching.
9. Thigh rear muscles group stretching.
10. Proprioception exercises (fig. 3)
11. After reaching full extension and bending, at least 90°, complex motions and plyometric exercises were included.



Fig. 3. Proprioception exercises

Results

Some researchers pay more attention to knee-joint arthrofibrosis of meniscus resection along with anterior cruciate ligament reconstruction. Scientists prove that isolated resection of menisci without anterior cruciate ligament reconstruction in knee joint with frontal medial instability causes to fewer cases of arthrofibrosis than reconstruction of anterior cruciate ligament with resection of menisci (Austin K.S., 1993).

Earlier, researchers believed that probability of arthrofibrosis development is increased by anterior cruciate ligament reconstruction in subacute period. But, not all researchers shared the same opinion (Hunter R.E., Mastrangelo J., Freeman J.R., et al., 1996; Majors R.A., 1996; Marcacci M., Zaffagnini S., Iacono F., et al., 1995). Based on present-day views, selection of optimal time for anterior cruciate ligament reconstruction is a clinical decision. However, when a mechanic block is missing, a patient is recommended to reach full volume of motions in knee joint prior to operation. Usually, a time span of 4-6 weeks after injury is needed for it. However, some patients do not have inflammation changes in knee joints and reach full volume of motions in 1-2 weeks after the injury.

Donald Shelbourne (1996) pointed out 4 variants or stages of knee-joint arthrofibrosis (Shelbourne K.D., Patel D.V., Martini D.J., 1996):

- 1) $< 10^\circ$ loss in extension and normal bending of a knee joint
- 2) $> 10^\circ$ loss in extension and normal bending of a knee joint
- 3) $> 10^\circ$ loss in extension and $> 25^\circ$ loss in bending of a knee joint with tough-motion knee cap
- 4) $> 10^\circ$ loss in extension, 30° and over of a loss in bending of a knee joint, and low placement of a knee cap (patella infera) with a distinct tough motion of the knee cap.

Hardly can these be called stages. These are rather independent variants of pathology development depending on prevailing localization of the paunch process or other factors. Not all patients having arthrofibrosis undergo this sequence of stages. With a significant number of patients, pathological process starts forming by one of these variants and does not aggravate, or a significant deficit of bending range (over 30°) with insignificant extension deficit (up to 10°), which does not fall under any variants by Shelbourne, develops.

With our patients, deficit of range of motions at the beginning of physical therapy, in 8 and 12 weeks of physical therapy course averaged $6,3 \pm 3,7$, $2,5 \pm 2,4$ та $2,4 \pm 1,8$ points for extension, and $33,6 \pm 24,6$, $18,9 \pm 16,7$, $8,0 \pm 8,0$ points for bending respectively (fig. 4). Thus, on average, after 8 weeks of physical therapy, extension range was improved by 3,8 points; bending range was improved by 14,7 points, while after 12 weeks – by 3,9 and 25,6 points respectively.

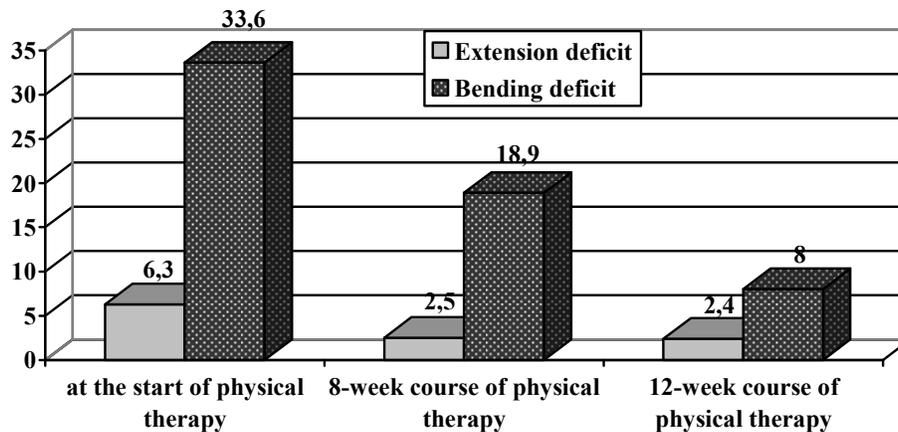


Figure 4. Deficit of range of motions of patients having arthrofibrosis after anterior cruciate ligament reconstruction at the start of physical therapy, in 8 and 12 weeks after its course (points)

Output level of activity by Tegner and Lysholm scales with patients having knee-joint arthrofibrosis after primary or revision anterior cruciate ligament reconstruction when consulting a doctor averaged $1,5 \pm 1,2$ and $46,1 \pm 13,4$ respectively. In one year after anterior cruciate ligament reconstruction and after a course of physical therapy it was $5,5 \pm 2,1$ and $89,6 \pm 9,6$ points respectively (fig. 5).

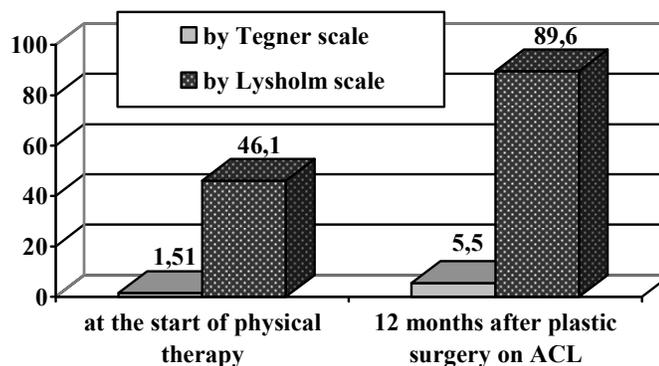


Figure 5. Dynamics of the level of activity by Tegner and Lysholm scales for patients having knee-joint arthrofibrosis after primary or revision anterior cruciate ligament reconstruction at the moment of consulting a doctor and after completion of physical therapy, one year after the operation (points)

Three of our patients (two after revision anterior cruciate ligament reconstruction and one after primary anterior cruciate ligament reconstruction) could not reach sufficient range of motions and sufficient improvement

of the function to return to sports on a desired level. These patients underwent surgical treatment – arthroscopic arthrolysis. All these three patients complained on limited extension, which could not be improved with physical therapy. Sufficient bending level could be reached for all patients. The worst levels of bending were observed with patients transferred for surgical treatment; however, even such levels of bending deficit were not their primary complaint. Two out of these three patients would not agree to undergo surgical procedure only because of bending deficit. The main reason was limited extension in knee joint. This proves better results of physical therapy in reaching bending at arthrofibrosis than in reaching extension. It also proves greater importance of full extension for knee joint function. When examined in later terms (one year after the operation) all patients experienced whether an increase of the range of motions in all directions or no changes. No deterioration of the range was observed with all 26 patients. It contradicts data in references, according to which stopping of training with a physical therapist provokes certain regress in functional results of a part of patients. This can be explained by the contingent of our group (all patients were motivated athletes). Thus, we may assume that motivated experienced athletes can reach better results with physical therapy both in nearest and far perspective.

Our research was limited by Tegner and Lysholm scales in one year after primary or revision anterior cruciate ligament reconstruction regardless of the term after the start or completion of physical therapy. Most of patients had already completed the necessary course of physical therapy by that time and they continued individual practices. However, since it was impossible to fully estimate athlete's functional ability within one year after the operation, only one of the parameters for research standardization had to be chosen – during the course of physical therapy or after the operation. We chose time after the operation as the most important index, since physical therapy was started at different stages in the research group. Also, we did not have a control group of patients having arthrofibrosis after anterior cruciate ligament reconstruction, who would not undergo physical therapy. It was stipulated by ethical reasons as athletes could not be left without adequate rehabilitation program. Athletes often quit physical therapy due to lack of motivation. However, we did not find such athletes to form a control group.

Arthrofibrosis shall be conceded when there is no increase in motions volume despite conducting standard after-operational or post-injury rehabilitation. However, it should be realized that not every case of knee joint stable contracture is a result of arthrofibrosis. It can be caused by joint block at meniscus tear or incorrectly placed transplant of cruciate ligament.

In first two weeks after an injury or operation, it is quite difficult to reveal signs of arthrofibrosis as a regular post-injury and post-operation period may have similar course; however, after the sixth week, conservative treatment of arthrofibrosis is ineffective. That is why arthrofibrosis should be diagnosed for during this period. Limited motions can be noticed not from the first weeks. A patient may have positive dynamics of motions at first that can slow down and stop at a certain stage. An even more aggravating symptom is decrease and loss of previously reached during first weeks after the injury or operation volume of motions compared to procedures of physical therapy.

However, it should be remembered that the reason for lack of progress of the volume of motions during exercise therapy and physiotherapy may not be only arthrofibrosis. In this case, differential diagnosis should be done with: other mechanical factors (free bodies, menisci tears in a form of a watering can, inaccurate transplant of anterior cruciate ligament etc.), dysfunction of neuromuscular conductivity (namely in a quadriceps femoris), or neural injuries, productive synovitis (including inflammation genesis), injury to any of the elements of extension apparatus of a knee joint, joint incongruency (namely due to internal joint displaced fracture). These pathological states can be independent pathologies or can provoke development of arthrofibrosis.

Though development of arthrofibrosis was preceded by surgical procedure with all patients, there is no single answer to the following question: “What is the key reason of development of arthrofibrosis. Is it an injury, operation, inadequate rehabilitation, or concurrence of these factors?”

Dysfunction of extension apparatus due to pain, contracture, dysfunction of neuro-muscular control, loss of strength or hypotrophy of quadriceps femoris, and, possibly, due to application of tourniquet during the operation leads to low placement of knee cap or infrapatellar contracture syndrome. Early knee cap mobilization, exercises for quadriceps femoris, electromyostimulation, kinesiotaping, rational orthosis in most cases and other actions allow prevention of this problem.

Discussion

Commonly, arthrofibrosis is a painful limitation of motions caused by excessive formation of paunches and proliferative changes in soft tissues (Gollwitzer H., Burgkart R., Diehl P., et al., 2006). In most cases, arthrofibrosis is excessive formation of scar tissue in a joint. However, part of these researchers refers it to external scar processes. Some consider arthrofibrosis to be a contracture that reaches certain indices of motion limitation (Vander Have K.L., Ganley T.J., Kocher M.S., et al., 2010). However, these statements are debatable. In any case, the majority of researchers share their views on the role of reduction of joint cavity volume in pathogenesis of contracture development at arthrofibrosis. The role of joint volume reduction in pain syndromes of knee joints of unidentified genesis that can be manifestations of moderately expressed arthrofibrosis, and positive effect of arthroscopic procedures that increase the volume of a joint (resection of synovial folds,

arthrolysis and/or release of anterior interval) have been proven by Dregoo J.L. and others (Dragoo J.L., Miller M.D., Vaughn Z.D., et al., 2010).

Still, there are debates whether arthrofibrosis is an independent nosological unit or it is just a pathogenetic component of joint contracture. The majority of researchers tend to think that arthrofibrosis is a complication of injuries and operations on joints, which causes its limited motions (mainly bending and extension). Histologically, fibrous changes in infrapatellar fat pad of patients after arthroscopic reconstruction have been proven back in 1997 by Murakami S. and others (Murakami S., Muneta T., Ezura Y., et al., 1997). More often, arthro-fibrosis develops in the knee joint. But it is possible that it is simply more studied in the context of complications of operations in this segment. Most often, arthro-fibrosis complicates the postoperative period after plasticity of the anterior cruciate ligament and occurs in 4-35% of cases (DeHaven KE, Cosgarea AJ, Sebastianelli WJ, 2003; Min B.H., Lee Y.S., Lee Y.S., et al., 2011). Often, arthro-fibrosis is a more severe pathology than the instability of the joint that was the subject of the intervention. Repeated surgical interventions for arthro-fibrosis are performed in 6.3% of cases after PCH plastics within 6 years of observation (Hettrich C.M., Dunn W.R., Reinke E.K., et al., 2013).

Pathologically, it is considered that scar tissue at arthrofibrosis is formed from adhesions (commissures) as a result of their “maturing” at excessive resistance of connective tissue to traumatization. Later, fibrous tissue of adhesions (commissures) shrinks reducing the volume in the joint, and then expands. At the same time, joint capsule slowly contracts.

Nowadays, researchers study genes that can stipulate it (Skutek M., Elsner H.A., Slateva K., et al., 2004). According to the research by F. N. Unterhauser and others (2004), development of arthrofibrosis depends on content of myofibroblasts and overall quantity of cells in connective tissue. Anterior cruciate ligament reconstruction causes stimulation of fibroblasts; however, arthrofibrosis does not develop in any case of such operations. Hence, output quantity of myofibroblasts can most probably be a prerequisite of arthrofibrosis development (F. N. Unterhauser, U. Bosch, J. Zeichen, A. Weiler, 2004).

Cosgarea A.J. and others (1995) noticed lower frequency of arthrofibrosis after immobilization of knee joint in extended position than in bent position under 45° and at earlier start of post-operation motions (Cosgarea A.J., Sebastianelli W.J., DeHaven K.E., 1995). However, it is difficult to analyze frequency of arthrofibrosis that appears only as a result of immobilization as immobilization is usually applied when there is a certain problem that can itself trigger arthrofibrosis. Despite that, present-day tendency is to mobilize knee joint as early as possible. Besides immobilization, arthrofibrosis can be provoked by both inadequate rehabilitation program and patient's inobservance of rehabilitation plan (Noyes F.R., Wojtys E.M., Marshall M.T., 1991; Noyes F. R., Berrios-Torres S, Barber-Westin S. D., Heckmann T. P., 2000).

Conclusions

Arthrofibrosis is easier to prevent rather than treat. That is why it is extremely important to reach maximum range of motions before the operation with the help of physical therapy, and restore muscles strength and function, especially of the knee joint extension apparatus. At the same time, important is development of motions not only in a form of flexing range, but in a form of rotational motions and motions (namely passive) in patella-femoral joint. Another important element is improvement and training of proprioception. For athletes, it is rather important to reach full range of the entire variety of motions as range of motions and joint control sufficient for an average person can be insufficient for athletes especially in a number of kinds of sport related to quick change of motions directions, rotational motions.

Conflicts of interest. The authors state that there's no conflict of interest.

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