

Anterior cruciate ligament reconstruction: single-bundle hamstring versus double-bundle reconstruction with lavsan (polyethylene terephthalate)

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Abstract: *Anterior cruciate ligament is one of the main stabilizateur of the knee joint. Many methods were suggested for its reconstruction with different allo- and autografts, as well as synthetic materials. The aim of study is to compare of two methods of ACL reconstruction. Material and metods. The study included 110 patients who underwent ACL reconstruction. I group (54 patients) underwent single-bundle ACL reconstruction with hamstring tendons, II group (56 patients) underwent double-bundle reconstruction with lavsan (polyethylene terephtalate) tape. Patients were evaluated with Lachman, anterior drawer and pivot-shift tests and Lysholm score. Results. Our results showed better results in double-bundle group, especially rotational stability was significant better. Conclusion. Independing of the method of ACL reconstructions these surgeries must be perform taking into account anatomic features and changes of the knee. Double-bundle technique of ACL reconstruction with lavsan provides better stability than single-bundle technique with hamstring tendons.*

Keywords: *anterior cruciate ligament, reconstruction, single-bundle technique, double-bundle-technique, synthetic material.*

Abbreviations: *ACL – anterior cruciate ligament*

BTB- bone-tibia-bone

LARS – Ligament Advanced Reinforcement System

AM – antero-medial

PL – postero-lateral

Introduction. Anterior cruciate ligament is one of the stabilizing structure of the knee. The incidence of ACL ruptures increased in recent times, now ACL reconstruction is one of most frequently performed surgeries in orthopaedics [1]. ACL ruptures may lead instability of the knee which result in disability of the knee in cutting and pivoting activities [2].

At present time two methods: single- and double-bundle reconstructions are used in ACL ruptures. A single-bundle ACL reconstruction means to restore the native anatomy of ACL as closely as possible and to achieve normal knee biomechanics [2]. In order to achieve it is necessary to follow the following principles: 1) to observe and to objectify native anatomy of patients; 2) to individualize each surgery according patient's anatomy; 3) to place

the tunnels and grafts at in the centre of patient's footprints; 4) to re-establish knee biomechanics by tensioning of the graft. In this method femoral and tibial tunnels must be positioned midway between the centres of AM and PL insertion sites.

Double-bundle reconstruction of ACL is explained with anatomic structure of ACL. ACL consists of two parts: antero-medial (AM) and postero-lateral (PL) bundles [1]. Both bundles are synergists but in different position of the knee they have different functions. Insufficiency of AM bundle shows increased antero-posterior translation of the tibia like in complete ACL rupture. Insufficiency of PL bundle result in instability with pivoting and turning. In double-bundle ACL reconstruction AM and PL tunnels are drilled separately at the native femoral and tibial sites. In both methods femoral tunnels can be drilled with using a transtibial or medial portal technique [1, 2].

Double-bundle reconstruction of ACL introduced to achieve better stability, particularly more stability for rotator loads [4, 5]. Some studies demonstrated that inability of single bundle reconstruction to restore intact knee rotational stability. [1]. But there are studies that don't show differences between a single-bundle and double-bundle technique, when placed anatomically and customized to the patient's anatomy [6, 7, 8, 9].

Despite at present time ACL reconstruction with auto- and allografts is popular, synthetic artificial ligaments are still used [3]. One of them is polyethylene terephthalate (lavsans), there are many reports about ACL reconstruction with this artificial ligament. Lavsan is a non-absorbable synthetic material containing polyethylene terephthalate fibres [10]. The use of artificial ligaments based on lack of donor comoridity, reduced operation time, abundant supply and enough strength and early loading of the operated extremity that result in shortening of rehabilitation period [3, 11, 12, 13]. Parchi P.D. et al. proposed the use of a synthetic graft for the ACL reconstruction to all patients older than 30 years with a symptomatic isolated ACL injury in order a quick return to their previous sport activity level as a possible alternative to the autograft [14].

Pan X. et al. reported about the similar results obtained at midterm follow-up in groups between bone –patellar-bone (BTB) and LARS groups [15]. Huang J. et al. concluded that the LARS artificial ligament has excellent biomechanical properties in comparing with autologous and allogenic tendons [13].

Materials and methods. Our study was included 110 patients with ACL rupture who underwent ACL reconstruction with hamstring tendons or double-bundle technique of ACL reconstruction with lavsan tape. Assessment was made with Lachman, anterior drawer and pivot-shift tests and Lysholm knee scoring scale.

First group included 54 patients (47 male, 7 female) who underwent ACL reconstruction with autograft of semitendinosus and gracilis. Lachman test was positive in all patients of this group: negative – no patients, +1 positive in 18 patients, +2 positive in 36 patients. Anterior drawer test was negative in 4 patients, +1 positive in 20 patients, +2 positive in 30. Pivot shift was negative in 7 patients, +1 positive in 20 patients, +2 positive in 27 patients. Lysholm score ranged from 42 to 72 (a mean score 64).

Second group included 56 patients (49 male, 7 female), who underwent ACL reconstruction with double-bundle (DB) technique with lavsan tape (polyethylene terephthalate). Lachman test was positive in all patients of this group: negative – no patients, +1 positive in 23 patients, +2 positive in 33 patients. Anterior drawer test was negative in 8 patients, +1 positive in 27 patients, +2 positive in 21 patients. Pivot shift was negative in 8 patients, +1 positive 25 patients, +2 positive in 23 patients. A mean score on Lysholm scale ranged from 48 to 74 points (mean 62 points).

The aim of study was to compare results of both methods of ACL reconstruction. Both techniques are made under spinal anesthesia in supine position of patient. Surgeries were

performed by different doctors of the same department who were masters of arthroscopic surgery.

Arthroscopic surgery is done with standart operative protocol. An arthroscope is inserted inside of the knee with using routine anterolateral and anteromedial portals. First all knee structures is inspected carefully, including meniscus, articular cartilage, synovial membrane. In case of meniscus tear the torn part of meniscus is resected. Then ACL reconstruction is performed using single- or double-bundle technique depending on patient's conditions, anatomy and individual parameters. Before surgery we plan our tactics. The main moment is a length of insertion side of ACL to the tibia. If it is more less 14 mm we used single-bundle technique. If length is more than 14 mm we used double-bundle technique if there are no contraindications as well short intercondular distance, severe osteoarthritis, bone marrow edema, rupture of other ligaments of the knee. In all cases femoral tunnels were drilled from inside to outside using anteromedial portal technique, and tibial tunnels were drilled from outside to inside.

Single-bundle technique of ACL reconstruction with hamstring tendons were performed with a standard procedure described in literature.

Double-bundle technique of ACL reconstruction with lavsan tape.

The same portals were used for this technique. After arthroscopically revealing of ACL rupture the knee is flexed to 110° and two femoral tunnels is drilled at insertion sites of both bundles of ACL. First tunnel is drilled at insertion site of PL (posterolateral) bundle of ACL. It is drilled with guide pin first, then with drill diameter of 4 mm along the whole lateral condyle of the femur. In order to make the second tunnel a drill bit put to the insertion site of AM (anteromedial) bundle and it is drilled with guide pin first, then with drill diameter of 4 mm along the whole lateral condyle of the femur (Fig.1, fig. 2: 1-and 2-tunnels).

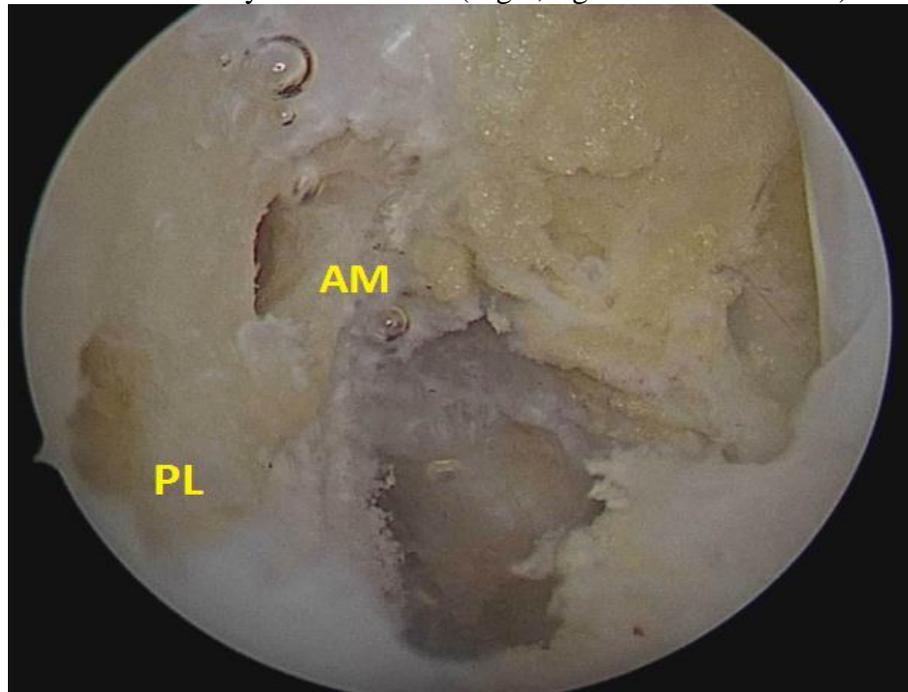


Fig. 1. Arthroscopic view of drilled femoral tunnels. AM – anteromedial tunnel, PM – posterolateral tunnel.

After that knee flexed under 90° and the tip of the conductor is put to the insertion site of PL bunble of ACL at tibia. Conductor is placed on 45-50° to the articular surface of plateau of the tibia, appr. 3,5-4,0 cm medially from the tibial tuberosity. It is drilled with guide pin first, then with drill diameter of 4 mm from outside to inside (fig.2, 3-tunnel).

Then the tip of the conductor is put to the insertion site of AM bundle of ACL at tibia. The conductor is placed on 60-65° to the articular surface of plateau of the tibia, appr. 1,5-2,0 cm medially from the tibial tuberosity. It is drilled with guide pin first, then with drill diameter of 4 mm from outside to inside (fig.2, 4-tunnel).

After drilling tunnels, one end of the lavsan tape of 5 mm width is inserted first to the 3-tunnel (PL tunnel of tibia), then 1-tunnel (PL tunnel of femur) respectively. End of the lavsan tape is pulled out outside with minimum 5 cm length incision on lateral condyle of femur. Second end of the lavsan tape is inserted first 4- and 2- tunnels respectively (AM tunnels of tibia and femur respectively), then this second end is pulled out on the lateral condyle of femur with minimum 5 cm length incision on lateral condyle of femur. After pulling out of lavsan tapes 3,0 cm sized incision is made above on lateral femoral condyle (the scheme of double-bundle-technique is prescribed on fig. 2. Both ends of the lavsan tape are pulled out from this incision and tied into a knot (Fig. 2). The extra ends of the lavsan tape above the knot are cut. Drainage of wounds is made, sutures is put. Aseptic bandages. With this way AM and PL bundles of ACL is created with a lavsan tape (Fig. 4). MRI is done after surgery (Fig. 5).

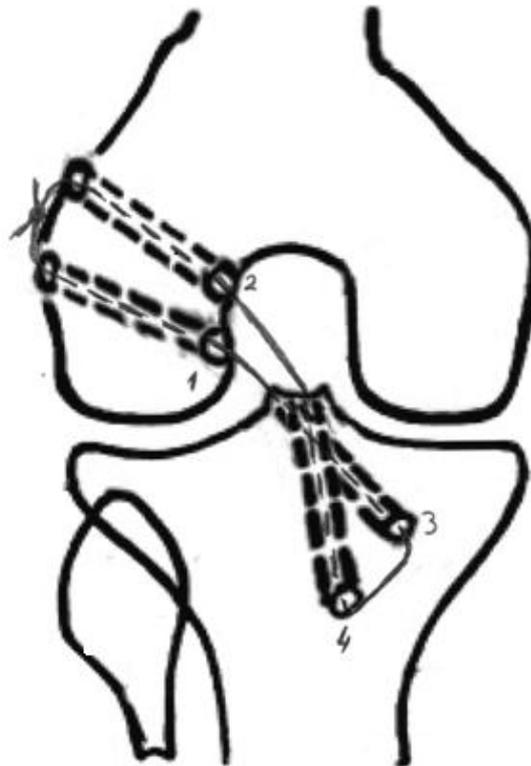


Fig. 2. Scheme of double-bundle ACL reconstruction. 1- PL tunnel in the femur, 2- AM –tunnel in the femur, 3-PL tunnel in the tibia, 4-AM tunnel in the tibia.

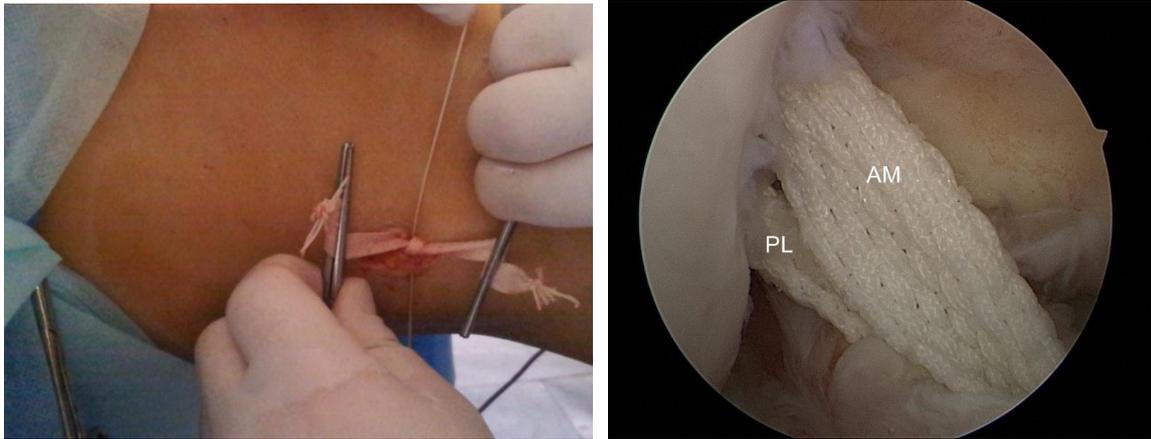


Fig. 3. Tying a not of the lavsan tape. Fig.4. Arthroscopic view after double-bundle ACL reconstruction with lavsan tape. AM –anteromedial bundle, PL – posterolateral bundle.

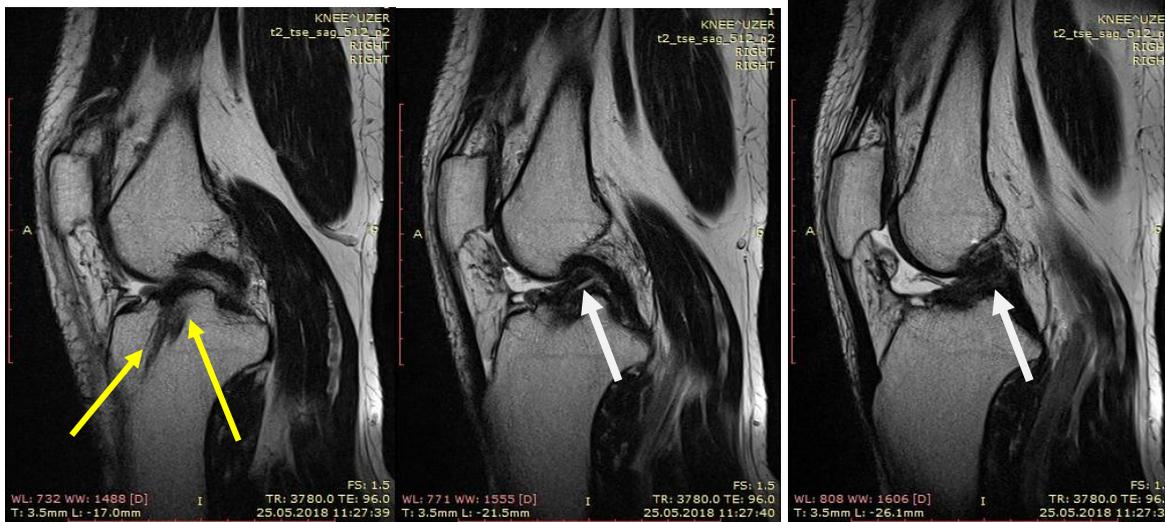


Fig. 5a.

Fig/ 5b.

Fig 5c.

Fig. 5. MRI of patient with double-bundle technique in 1 year after surgery. Fig 5a) drilled femoral tunnels (yellow arrows). Fig 5 b, c). Ligamentization of lavsan tape is seen (white arrow).

Postoperative treatment is done by a standard management of ACL reconstructed patients. Plaster cast was put to the operated extremity for 10-12 days period. In order to prevent hemarthrosis and swelling ice packs were put regularly 10-15 minutes per hour to operated knees up to 10-12 days. From the next day of surgery isometric exercises of the knee were recommended to prevent hypotrophy of muscles. Medications (antibiotics, anticoagulants, antiinflammation remedies and etc.) are recommended following standards of treatment.

Walking was permitted from the next day of surgery with crutches till 4 weeks. In 10-12 days plaster cast is removed and passive range of motions in the knee (flexion, extension) are recommended. Strengthening exercises of quadriceps muscle are recommended step by step. Return to sport is recommended from 6-9 month after surgery, depending on condition of patients.

Results. All patients were followed up at 14-18 month period. At follow up period all patients of both group felt the state of their knees to become better. No major complications occurred as well as venous thrombosis, pulmonary embolism, intrarticular infection in both

groups. Lachman, anterior drawer and pivot-shift tests were checked at follow up and patients accessed with Lysholm score. Concerning results of antero-posterior stability results were better in 2-group. Lysholm score was higher in 2-group in compare to SB group. Concerning of pivot shift test better results achieved in DB-group.

1-group. Lachman test was negative in 42 patients, + 1 positive 12 patients, +2 positive no patients. Anterior drawer test was negative in 48 patients, +1 positive in 6 patients, +2 positive no patients. Pivot-shift test was negative in 43 patients, 1+ in 11 patients. A mean Lysholm score was grown up to 86 (range between 76 to 100).

2-group. Lachman test was negative in 50 patients, +1 positive 6 patients, +2 positive no patients. Anterior drawer test was negative in 53 patients, +1 positive in 3 patients. Pivot-shift test was negative 54 patients, +1 positive in 3 patients. A mean Lysholm score was grown up to 90 (range between 78 to 100).

Table 1. results of treatment of ACL rreconstruction of both groups.

Groups		Lachman test			Anterior drawer test			Pivot shift test		
		negative	+ 1	+ 2	nega- tive	+ 1	+ 2	nega- tive	+ 1	+ 2
1-group	preop	-	18	36	4	20	30	7	20	27
	postop	42	12	-	48	6	-	43	11	-
2-group	preop	-	23	33	8	27	21	8	25	23
	postop	50	6	-	53	3	-	54	2	-

Synovitis occurred in 6 patients (3 from I group, 4 from II group) till 2-3 month period after surgery. Synovitis was successfully treated with antiinflammation remedies, ice packs, antibiotics, and intraarticular glucocorticosteroids.

Discussion. Many studies showed that results of ACL reconstruction with artificial ligaments were successful [3, 15, 16, 17]. Krudwig W.K. reported about good results in patients with their satisfaction and anteroposterior satability in patients with artificial Trevira-Hofest devices [12]. Lavoie P. et al reported about good clinical results with using LARS artificial ligament at 8-45 follow up in 47 patients [18]. But there are many reports about complications of artificial ligament (tear, foreign-body reactions, synovitis, recurrent instability) [11, 19, 20, 21, 22]. Gao K. et al. reported about developed only one case of synovitis (from 159 patients) with overall complications rate 5,7% after ACL reconstruction with LARS in his a multicenter study in with 3- to 5-year follow up [23].

In our study we watched synovitis in a few patients, who were prescribed medications and ice packages, in severe synovitis we used puncture of the operated knee with administering glucocorticosteroids.

Our patients of 1-group felt pain and difficulties during active flexion of operated knee, especially flexion after 90 dg. It is explained with a non anatomical position of the second end of lavsan tape. Perhaps, direction of the second end of a lavsan tape carried from the medial part of proximal tibia and it's transversal direction from the medial condyle to the lateral condyle bothered to achieve full range of motion of the knee.

Struwer J. et al and Lee J.H. et al. reported about synovial coverage of grafts during second look arthroscopy after ACL reconstruction with augmentation with a artificial ligament [17, 24]. Despite we did not perform second look arthroscopy we watched a ligamentization of artificial grafts in MRI made after at least a year after surgery in both methods.

It is necessary to take into account the details, which depends on human factor too. There are two problems which affects to the functional outcome of primary ACL reconstruction. First is a correct femoral and tibial tunnel placement. If to drill the tunnel too anteriorly on the femoral condyle it may lead to reduced knee flexion and instability of the knee. If to drill the tunnel too posteriorly on the lateral femoral condyle it may lead to reduced extension.

Second is a persisting instability after single-bundle ACL reconstruction [1]. ACL reconstruction focused only AM bundle reconstruction ignoring PL bundle leads to rotational instability. It is necessary to take into account that pivot-shift test is not objective but subjective assessment, it is done manually. The speed of the procedure, a magnitude of force applied to the knee and the abduction angle of the hip depends on examiner [25]. Several studies showed that there are not significant differences of results between single-and double-bundle technique when the graft placed anatomically [7, 8].

Conclusion. Our study showed that double-bundle reconstruction of ACL with lavsan provided better results than single-bundle technique with Hamstring tendons. It was seen especially in rotational stability. Besides that there were not problems of double-bundle group with restricting of range of motions of operated knee despite we did not use graft fixation devices. In choose ACL reconstruction technique it is necessary to take into account anatomic features and changes of the knee. Thus, independing of single-bundle or double-bundle technique, ACL reconstruction should be performed according an anatomic double-bundle structure of ACL.

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