INTRODUCTION

Anterior cruciate ligament (ACL) tear is a common injury, especially in young athletes. ACL tear can cause instability in the knee, difficulty walking, and reduced ability to work and play sports. If this lesion is not treat promptly, it can cause secondary lesions such as meniscus tear, articular cartilage injury, and joint degeneration. Therefore, for patients with strong athletic needs or participating in athletic activities, ACL reconstruction surgery is recommended.

Arthroscopic ACL reconstruction has been increasing with the developing of tunnel drilling techniques, graft marterials, and fixation devices. In the single bundle ACL reconstruction technique using 2-strand hamstring graft, the graft diameter is usually less than 8 mm. In multicentre studies, if the graft diameter is less than 8 mm, it increases the risk of rupture. And if the diameter of the graft is smaller by 1 mm, the failure rate increases to 45.7%.

Many of anatomical study of the ACL have report the anatomy of the femoral and tibial attachment site and the number of the ACL bundles. In that it is mentioned that in the ACL reconstruction surgery if the tibial and femoral tunnel is placed at wrong positions, the rate of failure will higher.

Studies of ACL anatomy and reconstruction suggest that if the tunnels are placed at the attachment site of the ACL, the kinematics of the post-operative knees will more similar to that on an intact knee joint versus the tunnels placement to achieve the most isometric knee.

In the all-inside ACL reconstruction technique using 4-strand hamstring graft, the length of the graft just 6 – 7 cm is long enough.

Therefore, the diameter of the graft is always greater than 8 mm. In Vietnam, there are no study of anatomical characteristics of the ACL attachment sites so that it can be used in the arthroscopic ACL reconstruction.

For this reason, we conducted a study entitled: “Study of the anatomy of the anterior cruciate ligament and the correlation in arthroscopic anterior cruciate ligament reconstruction with all-inside technique” with two objectives:

1. Measure the attachment sites and the size of the ACL on fresh cadaveric knees and compare with that in arthroscopic all-inside single bundle ACL reconstruction.

2. Evaluate the outcomes of the all-inside single bundle ACL reconstruction using 4-strand hamstring graft.

NEW CONCLUSIONS OF THE THESIS:

- The study of 20 fresh cadaveric knees of Vietnamese people showed that: the mean length of the anterior cruciate ligament (ACL) was 28.08 mm. We can determine two bundle structure of the ACL in 70% of the specimens. The mean sizes of the femoral and tibial attachment site of the ACL were 14.19 x 11.24 mm and 13.59 x 10.64 mm, respectively. The average distances from the center of the femoral to the Resident’s ridge and the posterior cartilage border of the lateral condyle were 5.67 mm and 8.26 mm, respectively. The average distances from the center of tibial attachment site to the ACL ridge and the RER ridge were 9.46 mm and 11.63 mm, respectively. The average distances between the centers of the attachment sites of two bundle on the femur and tibial were 9.1 mm and 9.39 mm, respectively.

- Correlation with the arthroscopic single bundle ACL reconstruction using all-inside technique: The length of the graft

must be at least 58 mm, the maximum diameter of the graft can be up to 11 mm. The largest femoral offset should be use is 8 mm, and the offset should be 2-3 mm smaller than the diameter of the graft. The tibial tunnel should be place at the center of the attachment site and the center of the tibial tunnel should be place at the midpoint of the medial aspect of the anterior horn of the lateral meniscus.

THESIS LAYOUT:

The thesis consists of 125 pages (excluding the references and appendices). There are 4 chapters, 44 tables, 69 figures, 7 charts. Introducing: 2 pages; Overview: 33 pages; Materials and methods: 28 pages; Results: 28 pages; Discussion: 31 pages; Conclusion: 2 pages; Recommendations: 1 page; 165 references (18 in Vietnamese and 147 in English).

CHAPTER 1: OVERVIEW

1.1. The anatomy of the ACL in adults

1.1.1. Macro anatomy

The ACL originates from the posterior part of the medial surface of lateral femoral condyle. It runs distally, medially and anteriorly to inserts into the tibial attachment site which located just anterior to the intercondylar eminences. The ACL is surrounded by a synovial membrane so that although ACL is inside the joint, it is outside the synovium. The length of the ACL was very different in studies from 22 to 41 mm, with an average of 32 mm, and with a diameter of 7 to 12 mm. Girgis et al described the ACL with two bundles: anteromedial (AM) and posterolateral (PL) bundle. The AM bundle originates from the posterior and superior part of the ACL femoral attachment site, it runs distally and inserts on the anteromedial part of

the ACL tibial attachment site. The PL bundle originates from the distal part of the ACL femoral attachment site and inserts on the posterolateral part of the ACL tibial attachment site. The AM bundle is smaller than the PL bundle.

1.1.2. Micro Anatomy

The ACL is made up of multiple fiber bundles which is wrapped by the tendon membrane. Each bundle has diameter from 250 µm to several millimeters and includes 3-20 collagenous bundles. Each collagenous bundle is in the form of ripples and arranged in different directions, with a diameter of 100 to 250 µm.

1.1.3. Blood vessels and nerves:

The ACL is provided with blood from the middle genicular artery, which branches into the synovial membrane at the contact with the capsule within the fat pad under the patella.

The ACL receives the nerve branches from the tibial nerve (the posterior articular branch). These branches travel along the blood vessels to the ligaments and the terminal ends are the Golgi pressure receptors.

1.1.4. Anatomy of femoral ACL attachment site

The ACL attaches to the posterior part of the medial surface of the lateral femoral condyle in an oval shape area. The length and width of the attachment site are 11 – 24 mm and 5 – 11 mm, respectively. The axis of inclined longitudinal diameter is tilted at an angle of 26 ± 6º from the vertical line and the posterior margin of the attachment site is curve and almost parallel to the posterior cartilage edge of the lateral femoral condyle. The size of the femoral ACL attachment site varies between studies, the difference may be due to differences in research methods, measurement techniques and different ethnic groups. Anatomical studies of bony landmark at the femoral

attachment site are particularly important for the accurate identification of the femoral tunnel position in ACL reconstruction surgery. There are two important bony landmarks: The Resident's ridge and the bifurcate ridge. The Resident's ridge or lateral intercondylar ridge is a bone ridge or the slope change of the medial surface of the lateral femoral condyle at the posterior three fourths position of the intercondylar notch and runs distally just anterior the femoral ACL attachment site. The bifurcate ridge is a bony ridge that runs from the anterior to posterior at the attachment site of the ACL and is the boundary of the AM and PL bundle.

The center of the attachment site of the AM and PL bundle was determined by Bernard on radiography based on Blumensat line and calculated as a percentage. The center of the AM bundle is located at 26.4% of the Blumensat line, while the PL the center of the PL bundle at 32.4% from posterior margin.

1.1.5. Anatomy of tibial ACL attachment site

The fibers of the ACL spread out when reaching the tibial plateau. The tibial attachment site is a triangular shape, with the top is at posterior side and the base is at the anterior side, 10-14 mm from the anterior edge or the tibial plateau. This site is located just anterior and lateral to the medial intercondylar eminence. The width of the attachment site is about 11 mm (8 – 12 mm), the length in the anterior-posterior direction is about 17 mm (14 – 21 mm). Philippe Colombet et al in 2007 reported the distance between the center of the attachment site of the AM bundle and the RER ridge was 17.5 ± 1.7 mm and the distance between the center of the attachment site of the AM and PL bundle was 8.4 ± 0.6 mm. The location of the tibial attachment site is more anterior than that of previous studies of Jackson D. W and Morgan C. D, who report that the center of the

tibial attachment site was 7 mm anterior to the anterior margin of the PCL attachment site.

On the lateral view knee x-ray, the position of the tibial ACL attachment site is determined based on Amis-Jakob line. This line passes through the posterior corner of the tibial plateau and parallel to the medial tibial surface. The center of the PL and AM bundles was determined to lie at 52% and 36% of the Amis-Jakob line from the anterior edge of the plateau.

1.2. Anatomy of pes anserinus

Gracilis and semitendinosus run with the sartorius from the femur and insert to the medial site of the proximal tibia. This site is about 20 mm wide, lie 19 mm distally and 22.5 mm medially to the tibial tubercle.

The sartorius originates from the anterior superior iliac spine, runs distally and medially through the anterior surface of the femur. At the distal part, the sartorius becomes thin and wide, it inserts to the anteromedial site of the proximal tibia and covers the insertions of gracilis and simitendinous. The tendon is the shallowest component of the Hamstring tendons. The tendinous fibers merge with the layer I (the fascia) of the thigh, making it difficult to recognize these two components at the insertion.

The gracilis originates from the inferior margin of pubic symphysis, runs distally at medial surface of the thigh and inserts to the proximal tibia with the semitendinosus tendon. This is a long, lozenge-shaped muscle that is the shallowest and weakest in the adductors group.

The semitendinosus originates from the posterior portion of the ischial tuberosity (common tendon with long head of biceps femoris and semimembranosus). This is a long, lozenge shaped muscle and the tendon part accounts for two-thirds of the total muscle. This

muscle runs at the medial and posterior surface of the thigh and inserts to the proximal tibia with the gracilis and sartorius tendon.

In the ACL reconstruction surgery, the gracilis and semitendinosus are used as grafts, the function of these muscles will be carried out by the remaining muscles, including: semimembranosus, sartorius, biceps femoris, gastrocnemius, adductors… Thefore, this does not affect the function of the limb.

1.3. Arthroscopic ACL reconstruction techniques

1.3.1. The techniques of tunneling (inside out, outside in, all inside…)

There are 3 basic techniques for tunneling:

- Create the femoral tunnel from the outside (outside-in)
- Create the femoral tunnel from the inside (inside-out)
- Create both femoral and tibial tunnel from the inside (all-inside)

1.3.2. Surgical techniques according to anatomical structures

1.3.2.1. Single bundle ACL reconstruction

This is the classic and the most popular technique today. The ACL is reconstructed by creating a femur and a tibial tunnel to insert the graft.

1.3.2.2. Double bundles ACL reconstruction

In the double bundles ACL reconstruction technique, both AM and PL bundle of the ACL will be reconstructed at their anatomical positions. We will create 4 tunnels, 2 at the tibia and 2 at the femur. Numerous studies on the world have reported results of double bundles ACL reconstruction surgery with good anti-slipping and anti-rotation, and almost completely recovering the range of motion.

In addition to the double bundles ACL reconstruction technique with 4 tunnels, there are non-anatomic double bundles ACL reconstruction

techniques with 3 tunnels, according to Darren A Frank, Bertrand Sonnery-Cottet, Jin Hwan Ahn.

1.3.3. Methods in graft fixation

1.3.3.1. Bone to bone graft fixation

Typically for this type of fixation is bone-patellar tendon-bone (B-PT-B) graft, of Achilles tendon-bone graft. The main fixation devices are interference screws, which are placed parallel to the graft in the tunnels. In addition to the interference screws, the tendon-bone graft can be fixed in the tunnel with the hanging button as Endo Button (Smith & Nephew)

1.3.3.2. Tendon to bone graft fixation

Tendon grafts without bone part, typically Hamstring tendon grafts, are most commonly used today in ACL reconstruction surgery. As a result, the fixation of tendon graft has been strongly studied and a number of fixation devices have been developed: the horizontal screw, hanging button as Endo Button, interference screw…

1.3.4. Types of graft materials used in the ACL reconstruction

The graft sources used for the ACL reconstruction surgery include: allografts, autografts, synthetic grafts.

1.4. Cadaveric anatomical studies of ACL attachment site in Vietnam and worldwide.

1.4.1. Studies on the world

There have been many authors studying the ACL attachment site on the fresh frozen cadaveric knees such as Siebold (2008), Maestro (2009), Kulkamthom (2012), Ferretti (2012), Ahmad and Ali (2013), Smigielski (2015), Pau Iyaji (2016) and they have provided indicators of sizes, the relevance of these indicators to the tunnel creation and graft fixation.

1.4.2. In Vietnam

Trang Manh Khoi et al. in 2008 reported an anatomical study of 47 formalin fixed knees of Vietnamese adults. The average size of the femoral and tibial attachment site were 17.1 x 10 mm and 16.2 x 11.2 mm, respectively. The average length of the ACL was 28.4 mm. Chu Van Tue Binh in 2010 reported an anatomical study of 20 formalin fixed knees of Vietnamese adults. The average size of the femoral and tibial ACL attachment site were 17.33 x 9.03 mm and 13.91 x 12.08 mm, respectively.

1.5. Studies of all-inside ACL reconstruction in Vietnam and worldwide

1.5.1. On the world

The "all-inside" technique was firstly introduced by Cerruili G and then by authors such as James H. Lubowitz (2011), Buda R., Wilson A.J., Matthew Brown, Seiji Watanabe, Mark Schurz, Octav Russu and Sam K Yasen… reported postoperative outcomes using hamstring tendon. This method has the advantage that the graft is larger due to 4-strand graft, two ends of the graft is stably fixed by hanging buttons. This help the knees to achieve good stability and recovery.

1.5.2. In Vietnam

The single bundle all-inside arthroscopic ACL reconstruction is a new technique that is of special interest. Recently, there are a number of studies by authors such as Tang Ha Nam Anh, Le Van Muoi, Nguyen Manh Khanh, etc, have reported good results of the single bundle all-inside ACL reconstruction using hamstring tendon.

CHAPTER 2: MATERIALS AND METHODS

2.1. Study Design: Descriptive prospective study

2.2. The subject of the study

2.2.1. Anatomical study: Measurement the sizes of ACL and its attachment sites on the fresh knees in Vietnamese adults at the Department of Anatomy - Ho Chi Minh University of Medicine and Pharmacy, Pham Ngoc Thach University of Medicine and the Department of Pathology – Saint Paul general hospital. Sample size: 20 fresh-frozen knees.

2.2.2. Clinical study: Including 68 patients with ACL injury who were treated by the single bundle all-inside arthroscopic ACL reconstruction using gracilis and semitendinosus graft at Saint Paul general hospital between September 2015 and June 2016.

2.3. Inclusion criteria

2.3.1 Inclusion criteria of the anatomical study: Fresh cadavers or fresh knees of adults, no knee injuries, good preservation, never used for study and research, randomly selection.

2.3.2. Inclusion criteria of the clinical study: We selected patients with high mobility needs who have been diagnosed with ACL injury with no other ligaments injuries.

2.4. Exclusion criteria

2.4.1. Exclusion criteria of the anatomical study: Fresh cadavers and fresh knees have injury within the knee, not properly preservation.

2.4.2. Exclusion criteria of the clinical study:

- Patients with other ligaments injuries: posterior cruciate ligament, medial collateral ligament, lateral collateral ligament.

- Patients with previous injuries of lessions of the bone or cartilage around the knee joint.

- Patients who did not agree to participate in the study.

2.5. Research methods

2.5.1. Anatomical study of the ACL in Vietnamese adutls

We conducted a study on 20 fresh-frozen knees and evaluation:

- The length of the ACL within the knee joint

- Define the geometric centers of the ACL and its bundles attachment sites

- The distances from the centers of the femoral and tibial ACL attachment sites to the centers of the attachment sites of each bundle and to the relative landmarks.

- The distances between the centers of AM and PL bundle attachment sites.

2.5.2. Prospective study evaluating the surgical results

Based on the clinical tests such as Lachman's test, Pivot Shift test, routine knee X-ray assessment of the tunnels position, quantification of Lachman's test with the KT-1000 device. Evaluation of the knee function was performed according to Lysholm and IKDC scoring.

2.6. Data processing

Data collected from the study were processed according to computerized statistical algorithms on computer using SPSS software version 16.0.

CHAPTER 3: STUDY RESULTS

3.1. The results of anatomical study

3.1.1. The length and size of the ACL body

The average length of the ACL was 28.08 ± 1.01 mm. The average medial-lateral width at the midpoint of the ACL was 10.25 ± 0.73 mm. The average anterior-posterior thickness at the midpoint of the ACL was 5.88 ± 0.35 mm.

3.1.2. The anatomy of the femoral ACL attachment site

- Size: Average size of the femoral ACL attachment site was 14.19 x 11.24 mm.

- The distances from the center of the femoral attachment site to the anatomic landmarks is shown in Table 3.1.

Table 3.1: The average distances between the center of the femoral ACL attachment site to the anatomic landmarks (n=20)

Start point	End point	Mean ± SD (mm)	Range (mm)
The center of the femoral ACL attachment site	Resident's ridge	5.67 ± 0.11	5.43 - 5.91
	Inferior cartilage margin	12.54 ± 0.52	11.94 - 13.85
	Posterior cartilage margin	8.26 ± 0.55	7.65 - 9.13

In our study, 100% of the knees can be observed for Resident's ridge. All knee specimens can determine the distance from the center of the femoral ACL attachment site to the cartilage margins.

3.1.1. The anatomy of the tibial ACL attachment site

- Size: The average size of the tibial ACL attachment site was 13.59 x 10.64 mm.

- The distances between the tibial ACL attachment site and the anatomic landmarks is shown in Table 3.2.

Table 3.2: The average distances between the tibial ACL attachment site and the anatomic landmarks

Start point	End point	Mean ± SD (mm)	Range (mm)
The center of the tibial ACL attachment site	The ACL ridge	9.46 ± 0.41	8.96 – 10.30
	The posteromedial aspect of the anterior horn of the lateral meniscus	7.99 ± 0.38	7.13 – 8.15
	The RER ridge	11.63 ± 0.55	11.02 – 12.9

3.2. The surgical results

3.2.1. General characteristics

- Age: The mean age was 29.62 ± 5.80 years, most commonly in the 21-30 age group.

- Gender: The number of male patients was 54, accounting for 79.4% and 3.8 times more than the female patients.

- Injury mechanism: Mainly due to sport injury (51.5%), the remaining are traffic accident and home accident.

- Meniscus tear included: 66.65%, in which mainly medial meniscus tear (30.9%)

3.2.2. The size of the graft

- The length of the graft: The average length of the graft in our study was 62.8 ± 2.6 mm, range 58 – 70 mm.

- The diameter of the graft: The average diameter of the graft in our study was 8.92 ± 0.67 mm.

3.2.3. The results related surgery process

- The operative time: the average operative time is 90 minutes, most cases are less than 60 minutes.

- The length of the femoral tunnel: The average length of the femoral tunnel was 32.99 ± 2.81 mm, range 25 – 40 mm.

- The length of the tibial tunnel: The average length of the tibial tunnel was 33.56 ± 2.72 mm. The shortest tunnel was 25 mm.

- The tunnel position on x-ray: The average femoral tunnel position was 30.47 ± 1.97% of Blumensaat line, range 25% - 33%. The average tibial position was 39.04 ± 1.67% of Amis-Jakob line, range 35% - 43%.

- The range of motion after the surgery: The range of motion after the surgery was significantly improved. At 3 weeks after the surgery, almost of patients can flex the knee over 90º, and almost of patients can flex the knee over 120º at 6 weeks after the surgery and reached the normal range of motion after 12 weeks. We have two cases of 5º limited knee extension and two cases of 5º limited flexion.

3.2.2. The results of knee function after the surgery

At the time of 6 months after surgery, we examined all 68 patients at a rate of 100%.

- The Lysholm knee function score (n = 68) at 6 months after surgery is shown in Table 3.3.

Table 3.3: The Lysholm knee function score at 6 months after surgery

Lysholm score	Numer of patients	Percentage
Excellent (91-100 score)	56	82.4
Good (84-91score)	7	10.3
Moderate (65-83 score)	5	7.3
Poor (< 65 score)	0	0
Total	68	100.0
Mean ± SD	93.9 ± 4.7	
Range	77-100	

The average Lysholm score at 6 months after surgery was 93.9 ± 4.7. The rate of excellent and good results was 92.7%, there are 5 cases of moderate and no poor results. The preoperative Lysholm score was 58.84 ± 6.79.

- The IKDC score (n=37) at 6 months after surgery is shown in Table 3.4

Table 3.4: The IKDC score at 6 months after surgery

Grade	A	B	C	D	Total
N	54	11	3	0	68
Percentage (%)	79.4	16.2	4.4	0	100.0

Results in the IKDC score were normal (grade A) in 79.4% of patients, nearly normal (grade B) in 16.2% of patients. There were 3 cases of abnormal (grade C) IKDC score and there were no cases of poor results (grade D).

* The results of clinical tests:

- The Lachman's test: Most patients (79.42%) have negative Lachman's test, 17.65% of patients have 1+ positive and 2 patients have 2+ positive Lachman's test.

- The pivot shift test: Most patients (88.2%) have negative pivot shift test, there were 8 patients (11.8%) of grade I positive test and there were no patients of grade II positive test.

- Single leg forward hop test: The average value of this test at 6 months after surgery was 94.87 ± 6.36%, this was 37.96% higher than preoperative value (56.91%). This difference was statistically significant with $t = 41.65$ and $p < 0.001$.

- The anterior tibial displacement measuring with the KT-1000: There was a marked improvement in the anterior tibial displacement on the KT-1000. The preoperative and postoperative displacement were 9.6 ± 2.03 mm and 2.62 ± 0.86 mm. The difference statistically significant with $t = 29.102$ and $p < 0.001$.

CHAPTER 4: DISCUSSION

4.1. Related anatomy in single-bundle all-inside ACL reconstruction technique:

The maximum graft diameter that can be used to reconstruct the ACL is 11 mm, in this clinical study the average diameter of our graft is 8.92 mm. Many authors have studied and found that the size of the graft is one of the factors contributing to the success of the surgery. If the diameter is less than 8mm, the risk of post-reconstructive ACL retear will increase. Each 1 mm decrease in diameter is equal to 45.7% increase in the rate of failure. However, the diameter of the

graft should not exceed the attachment site. Thus, with respect to the anatomy, the diameters in our clinical study were completely within the attachment site of the ACL.

The intracapsular mean length of the body of the ACL measured on Vietnamese people is 28.08 mm, according to Chen L., the graft in the tunnel must be from 15 to 20 mm. Thus, the graft length in the single-bundle technique must be at least 58mm. In our clinical study, the average length of the graft was 62.8 mm, the shortest graft was 58 mm. Therefore, the length of our grafts were good enough.

The average distance from the center of attachment site to the posterior cartilage margin that we measured in the anatomical study was 8.26 mm. Several studies have confirmed that when the center of the femoral tunnel moves anteriorly, resulting in malposition of the tunnel, the rate of failure related to anatomically incorrect tunnel placement will increase. So, only the maximum offset size of 8 mm should be used to ensure that the center of the attachment site is not displaced anteriorly first during the tunnelling process, and one should use the offset which is 2 or 3 sizes smaller than the graft size so that there are 2 to 3 mm left in the posterior wall of the tunnel. In our clinical study, the largest graft had the diameter of 10 mm so the largest offset we use is number 8, which satisfied the requirement that the center of the attachment site femoral tunnel is not displaced anteriorly.

4.2. Results of operation

4.2.1. Operation-related result

* *Operation duration:*

The mean operation duration in this study measured from skin incision to skin closure was 64.15 ± 14.03 minutes, in which the fastest was 40 minutes and the longest was 90 minutes. With a similar

technique to us, the average surgery time of Tang Ha Nam Anh was 61 ± 2.01 minutes and of Le Van Muoi was 72.2 ± 1.6 minutes.

* *The position of the femoral tunnel and the tibial tunnel:*

The position of the femoral tunnel in our study was: 30.47 ± 1.97% on the Blumensaat line from the posterior limit to the center of the tunnel, the lowest was 25% and the highest was 33%. This is similar to other studies: Colombet was 26.4 ± 2.6%, Tsukada was 25.9 ± 2.0%.

Average ACL tibial tunnel position in our study was 39.04 ± 1.67% on the Amis-Jakob limit from the anterior limit to the tibial tunnel center, the lowest was 35% and the highest was 43%. The results of Colombet's study, Tsukada' study and Tran Trung Dung's study were 36 ± 3.8%, 37.6 ± 3.6% and 34.7 ± 3.3%, respectively.

4.2.2. Knee joint functional recovery results

* *Lysholm scale results:*

The Lysholm score at 6 months postoperatively was 93.9 ± 4.7, the lowest was 77 and the highest was 100, in which Very Good was 82.4%, Good was 10.3% and no patient suffered poor result. The Lysholm score improved statistically significantly with 94.6 points at post-operative 12 months and 97.8 points at 18 months.

The results of ACL reconstruction with double bundle technique of local authors such as Le Van Muoi with the similar technique possessed the post-operative Lysholm score of 90.4 points, the percentage of Good and Very Good achieved 100% with the follow-up time of 12 months. Tran Anh Tuan reported the Lysholm average score of 96.1 points. The foreign authors reported on the results of the ACL reconstruction with single bundle all-inside technique using semitendinosus and hamstring such as Mohammad Mahdi Omidian, the average Lysholm score after 2 years was 91.5 ± 3.6 points. Octav

Russu et al reported the mean Lysholm score after an 18-month follow-up of 95.55 ± 4.63 points. Mean Lysholm score after 3 years was 92.8 ± 1.96 points in the study of Gobbi et al.

* *Evaluation with IKDC form*:

Our study results included 54 patients with Grade A (79.4%), 11 patients with Grade B (16.2%) and 3 patients with Grade C (4.4%).

Local authors, who studied the surgical reconstruction of ACL, such as Dang Hoang Anh reported 69.6% of Grade A, 23.9% of Grade B and 6.5% of Grade C. Ha Duc Cuong found that Grade A and Grade B accounted for 91.2%. Nguyen Nang Gioi used autogenous patellar tendon graft with 73.2% Grade A, 19.8% Grade B, 3.5% Grade C and 3.5% Grade D.

Foreign authors such as Kondo and colleagues evaluated 171 cases with IKDC form. The results were 110 cases (64.3%) of Grade A, 53 cases (31.0%) of Grade B, and 8 cases (4.7%) of Grade C. Siebold et al. reported 35 cases assessed with IKDC form including 78% of Grade A, 19% of Grade B, and 3% of Grade C. The study of Gobbi et al. showed the IKDC form evaluation result of 21 cases of Grade A (70%) and 9 cases of Grade B (30%).

* *Clinical evaluation of stability and anteroposterior anti-displacement with Lachman test:* There were 54 negative cases, 12 cases Grade 1 positive, 2 cases of Grade 2 positive. Other authors such as Pham Ngoc Truong reported 54 cases in which 44 cases were negative, 9 cases were Grade 1 positive, and 1 case was Grade 3 positive. In the study of Fu and associates, the results of 96 cases assessed with Lachman test were: 64 negative, 30 Grade 1 positive, 2 cases Grade 2 positive.

* *Clinical evaluation of rotatory instability with Pivot Shift test:* We found a significant improvement with 60 negative cases accounted for 88.2% and 8 positive cases.

* *Evaluation of anteroposterior displacement with the KT 1000 calibrated Lachman test:* we obtained a mean anterior displacement of the tibial plateau of 2.62 ± 0.86 mm. This result is similar to the reports of Tran Trung Dung and Sam K which were 2.37 ± 0.81mm and 2.4 mm, respectively.

* *Evaluation of knee joint function with the single leg hop test:* the average of 6 months after surgery was 94.87 ± 6.36%, the lowest was 70% and the highest was 100% significantly improved compared with before surgery (56.91 ± 8.38%). Fu et al. reported the result of knee joint functional evaluation after two years with the single leg hop test of 94.2 ± 8.7%.

* Assessment of knee range of motion: The knee range of motion of the patients in our study progressed rapidly after surgery, with an average amplitude after 12 weeks of 135.3^0. After 6 months there was one patient with less than 5^0 loss of knee extension, and 3 patients with less than 5^0 loss of knee flexion. Gobbi reported an average knee range of motion of 134.5 ± 10. Fu found that the mean range of motion in the study group was 137 ± 90.

So, the knee joint function after surgery of the patient group in our study achieves highly positive results. All patients showed significant improvement with the majority can return to normal or nearly normal activity.

In our opinion, the reconstruction of ACL based on the anatomy of the ligament helps restore the ACL function by surgically rebuilding the size, the direction of the collagen fibers and the attachment site region similar to the original ACL.

A recent concept in the reconstruction of the DCCT is the restoration of the ACL full attachment to maximize the function and the biomechanical strength of the ACL. The authors suggest that the larger the area of the reconstructed attachement, the better the functional result, which will depend on the size of the graft and the direction of the drilling.

4.3. Factors related to the knee joint functional results

According to our study, the large size of the graft is significantly related to the surgical outcome. In fact, there is no concensus regarding the size of the graft in the reconstruction the ACL. A few studies by other authors such as Mariscalco and Magnussen showed that in the reconstruction of ACL with single bundle technique, there is a correlation between the diameter of the graft and the surgical outcome.

The location of the tunnel is a factor that apparently influences the results. Accurate localization of the tunnel implies that the ACL reconstruction will also resemble the direction of the original ligament. This depends on the surgeon's skill. Incorrect location of the tunnel can lead to the graft that lies outside the attachment site, trapped grafts, and incorrectly anatomically aligned ligaments.

The functional rehabilitation has a great influence on the outcome of the operation. Exercise programs should avoid overloading the graft during the healing process and promote the formation of proprioceptive receptors.

4.4. Complications

We had one case of more than 5^0 loss of knee extension six weeks after surgery. This patient was operated after a 4 week traumatic knee injury with meniscal tear that caused knee locking and more than 10^0 pre-operative loss of knee extension. This patient did not attend the

first follow-up. 6 weeks after surgery, the patient came to follow up for the first time. After the examination, the patient was admitted and instructed to exercise functional rehabilitation. The patient could extend the knee completely after 3 weeks. To avoid this complication, patients should strictly follow the appointment and the functional rehabilitation regimen after surgery.

There were three cases of wound infection. One case had wound infection after 2 weeks of surgery in the donor site. There was no infection in the knee joint. Patients were treated as out-patients by dressing, daily irrigation and antibiotics based on antibiotic susceptibility test. However, the patient occasionally had swelling and small local pus nodes on the surgical wound. This was resolved with antibiotics. After 5 weeks we re-opened the donor site to debride, gave more antibiotics and changed the dressing, the patient completely healed after 7 weeks. In the other two cases, the patients missed the 2 week post-op appointments. 5 weeks after surgery patients came back with the inflammed wound sites, where the thick yellow fluid came out via the fistula. Patients underwent debridement, were given antibiotics and dressing. The patients completely healed after 3 weeks. In our opinion, this complication may be due to hematoma in the tendon donor site, or due to the body reaction with the fixation devices such as Tight Rop button or infected resorbable sutures. To limit this complication, we thoroughly irrigate the wound site before closure.

We had 5 cases of numbness in the anterolateral side of the knee. This was due to the injury of the terminal branch of the infrapatellar branch of the saphenous nerve. The cause may be the tendon harvesting or the openning the hole for the endoscope. In general, these disorders have little effect on the patient's quality of life.

CONCLUSIONS

Through a study of 20 fresh knees of Vietnamese adults and the single bundle all-inside arthroscopic ACL reconstruction using hamstring tendon autograft in 68 patients. We made the following conclusions:

1. The sizes of the ACL and its attachment sites and the correlation in arthroscopic ACL reconstruction with all-inside technique:

- The femoral ACL attachment site:

+ The average size of femoral attachment site: 14.19 x 11.21 mm

+ The average distance between the center of ACL attachment site and the Resident's ridge: 5.67 mm.

+ The average distance between the center of the ACL attachment site and the posterior cartilage margin: 8.26 mm.

+ The average distance between the center of the ACL attachment site and the inferior cartilage margin: 12.54 mm.

- The tibial attachment site:

+ The average size of the tibial ACL attachment site: 13.59 ± 10.67 mm.

+ The average distance between the center of the tibial ACL attachment site and the RER ridge: 11.63 mm.

+ The average distance between the center of the tibial ACL attachment site and the ACL ridge: 6.46 mm.

- The ACL body:

+ The average length of the ACL: 28.08 ± 1.01 mm.

+ The width of the ACL at midpoint: 10.25 mm.

2. The results of the single bundle all-inside arthroscopic ACL reconstruction:

- The mean anterior tibial displacement at 6 months after surgery was 2.62 ± 0.86 mm, significant better than before surgery: 9.6 ± 2.03 mm.

- The rotary stability of the knee was restored well with 60 cases of negative pivot shift test and 8 cases of grade I positive pivot shift test.

- The mean range of motion of the knee was 135.3º, with only one case of < 5º extension limitation and 3 cases of < 5º flexion limitation.

- The single leg forward hop test was significant improved compared to the preoperative period with an average value of 94.87 ± 6.36% in comparison with the healthy leg.

- The Lysholm score was significantly improved at 6 months postoperative follow-up: 93.9 ± 4.7 versus 58.84 ± 6.79 at the time before surgery. The lowest and highest Lysholm score were 77 and 100, respectively. Lysholm score was excellent and good in 82.4% and 10.3% of cases, respectively. There were no poor Lysholm score.

- The IKDC score at 6 months after surgery: 54 cases (79.4%) of grade A (normal), 11 cases (16.2%) of grade B (nearly normal), 3 cases (4.4%) of grade C (abnormal).

RECOMMENDATIONS

1. The initial measurement results of the anatomy of the ACL attachment site in Vietnamese adults have provided some reference indices in the single bundle arthroscopic ACL reconstruction. However, further research is needed with a larger samples of knees specimens.

2. The good results of the single bundle all-inside arthroscopic ACL reconstruction have provided an alternative to tunnel drilling and graft fixation techniques.