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Assessment of proprioception improvement after anterior cruciate ligament reconstruction with tibial remnant preservation versus non remnant preservation

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***Abstract*---**Background: The ACL functions both as an anterior stabilizer and as a sensory organ. It is not only provides proprioceptive function, but also initiates protective and stabilizing muscular reflexes. Most ACLs are ruptured in the proximal half and most mechanoreceptors have been reported to be located in the sub-synovial layer near the tibial insertion of the ACL. Therefore, it is reasonable to preserve the remnant tissue. Particularly the tibial side, as a source of reinnervation if impingement and Cyclops can prevented. Objective: To compare proprioception after ACL reconstruction with remnant preservation versus non remnant preservation. Methods: This is a prospective single blind controlled randomized study was done from December 2015 to October 2017, it was conducted on forty patients (40 males). Divided into two groups

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twenty patients in each one to assess proprioception after anterior cruciate ligament reconstruction. Group (A) consisted of 20 patients with mean age 28±5.57 years who underwent to ACLR with tibial remnant preservation. Group (B) consisted of 20 patients with mean age 29.05±5.596 years who underwent to ACLR with non-remnant preservation were selected on the basis of clinical picture and imaging findings. Results: The results of the current study showed that there is a statistically significant difference between ACL with tibial remnant preservation versus ACL reconstruction only regarding position sense however there is no significant statistical difference regarding Lysholm score, IKDC objective tests. Conclusion: There is improvement of proprioception after remnant preservation versus non remnant preservation of ACL stumb, clinical relevant techniques and methods of objective assessment of knee proprioception should be further investigated.

***Keywords*---**ACL, Lysholm score, IKDC, PCL.

Introduction

Anterior cruciate ligament (ACL) injury, the most common knee ligament injury, will result in anterior translation of the tibia relative to the femur, valgus and rotatory laxity of the knee[1]. Because an injured ACL cannot naturally heal and will lead to an increase risk in developing osteoarthritis later in life[2]. Therefore, arthroscopic reconstruction of the anterior cruciate ligament (ACL) has been the conventional treatment strategy for the ACL injury. However, revascularization, tendon healing, bone tunnel healing and proprioception recovery of ACL reconstruction have been introduced to improve the function outcome and restore normal kinematics of the knee. Meanwhile, a remnant-preserving technique was developed to preserve the proprioception and enhance the revascularization of the reconstructed ACL [3]. There are three reasons to preserve these remnants: biomechanical, vascular and proprioceptive advantages for the patient. Good quality fibers work as graft protection during the healing process [4].

The role of mechanoreceptors in the ACL has attracted considerable attention [5]. Proper reconstruction of the ruptured ACL does not always have good results. Success after surgery may depend not only on mechanical stability but also on the quality of recovery of proprioception[6]. It is well known that most ACLs are ruptured in the proximal half [7], and most receptors have been reported to be located in the sub synovial layer near the tibial insertion of the ACL,[8-9] expected roles of tibial remnant are to enhance the revascularization, cellular proliferation of the graft, preserve proprioceptive function, some authors[10,11] proposed that pre inflammatory cytokines, such as tumour necrosis factor a (TNF-a), interleukin-1b (IL-1b) and interleukin-6 (IL-6), should be elevated in the synovial fluid after ACL disruption and reconstruction. The synovial fluid flows into the “dead space” between the graft and the tibial tunnel wall through the tunnel entrance, and the cytokines can cause osteolysis and tunnel enlargement. Various types of motion at the graft– tunnel interface before graft–tunnel incorporation occurs were also related to tunnel enlargement **[12]**. The remnant of ruptured ACL is removed to clearly visualize the ACL footprint or decreased the risk of impingement and cyclops lesion in most current technique for ACL reconstruction therefore, it seems reasonable to assume that preserving the tibial remnant as much as possible without causing impingement, would be of potential benefit to the patient. In additional, it would facilitate the vascular in growth of grafted ACL.[13]

Aim of the Work

To compare knee proprioception after ACL reconstruction with remnant preservation versus non remnant preservation.

Hypothesis

Theory suggests that remnant-preservation allows native tissue to grow into the graft. The presence of remnant tissues in the ruptured ACL, containing mechanoreceptors and free neural ends, can help reinnervate the ACL autograft.

Patients and Methods

From December 2015 to October 2017, a prospective randomized analytical clinical study was underwent for forty patients divided into two groups twenty patients in each one to assess proprioception after anterior cruciate ligament reconstruction.
Group A:
Patients undergoing anatomic single bundle ACL reconstruction with tibial remnant preservation.
Group B:
Patients undergoing anatomic single bundle ACL reconstruction without tibial remnant preservation

Inclusion criteria

Inclusion criteria for this investigation included acute ACL insufficiency in patients fulfilling the following criteria:

- Athletes and non-athletes patients.
- Males and females.
- Middle age (20-40) years old.
- Associated meniscus injury.

Exclusion criteria

Moderate to advanced knee osteoarthritis.

- Malalignment of lower limb.
- Multi-ligaments injury.
- Revision ACL.
- Associated chondral lesions

Methods

Twenty patients with primary acute ACL insufficiency who met the inclusion criteria underwent arthroscopically anatomic single bundle ACL reconstruction with tibial remnant preservation. The other twenty patients underwent ACL reconstruction with anatomical single bundle with non-remnant preservation all patients were followed prospectively for a minimum of six month, and all patients underwent for pre-operative assessment of:

- Lysholm scoring.
- Objective IKDC.
- Assessment of proprioception by the passive angle reproduction test (BIODEX) (BIODEX Medical Systems, Inc. New York. USA; Software, system 3 Quick-set, Rev M, version 3.30).

Graft fixation

Group A

Femoral fixation: The graft is pulled about 30 mm till the sutures end which disappear in the femoral tunnel and interference screw is used for femoral fixation which applied on the guide wire that passes in the tunnel then used the interference screw with the same size of the reamer. Tibial fixation: after cycling for 20 times with pulling of the graft from the tibial end we fixed the tibia with knee flex 30 degree by interference screw with size over by 1-2 more than the size of the tunnel. Then enter a lasso from the AM portal to turn around The new ACL then pass the prolene through the lasso to receive the prolene from the AL portal then loop of prolene was made and insert a vicryl NO 0 to pulled through the prolene and now the vicryle encircle the new ACL with the remnant fibers from the old ACL which pulled upwards through a grasper while a sliding note was been done and this suture repeated & tied (Fig. 1).

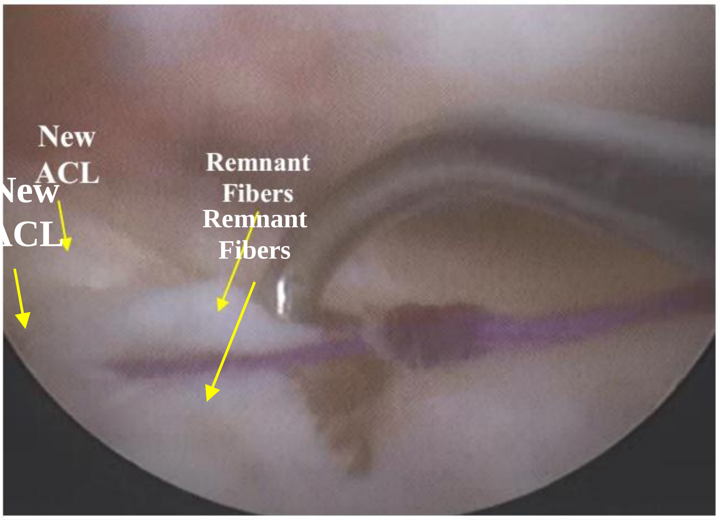

Fig. (1): Vicryle encircle the new ACL with the remnant fibers

Group B

Two interference screws are used for tibial and femoral fixation. Scopic assessment throughout full range of motion (ROM) to assess for impingement either on PCL or roof of the notch.

Statistical analysis

Data entry and master sheet were carried out using Microsoft Office Excel 2007. The analysis included descriptive analysis (frequency and percentage for categorical data – mean & standard deviation for scale data) Statistical analysis was conducted using SPSS for windows, version 23 (SPSS, Inc., Chicago, IL). The current test involved two independent variables. The first one was the (tested group); which had two levels (group A received tibial remnant preservation and group B received non remnant preservation. The second one was the (measuring periods); which had two levels (Pre-intervention, Post twelve months of intervention). In addition, this test involved three dependent variables (absolute proprioception error at 30 degrees and 45 degrees of knee flexion and lysholm score).

Results

The main purpose of this study was to investigate the effect of tibial remnant preservation on proprioception versus non remnant preservation in anterior cruciate ligament reconstruction.
The current study was conducted on 40 patients (40 males). They were divided into two groups. Group (A) consisted of 20 patients with mean age 28.3±5.57 years. Group (B) consisted of 20 patients with mean age 29.05±5.96.

Absolute proprioception error at 30 degrees knee flexion (pre and post-test for injured knee)

in group A the mean ± SD values of Absolute proprioception error at 30º knee flexion in "pre" and "post" intervention were 3.76±1.47 and 2.33 ±0.95respectively . There was significant reduction at post intervention in compare to pre- intervention (P-value =0.0001*) (Table 1).

In the group B the mean ± SD values of Absolute proprioception error at 30º knee flexion in "pre" and "post" intervention were 3.59 ±1.24 and 3.85±0.52 respectively. There was a significant difference at post intervention in compare to pre- intervention (P-value =0.018) (Table 1).

Between groups A and B there was no significant difference of Absolute proprioception error at 30º knee flexion in the pre-intervention (P-value=0.697). While there was significant difference in post-intervention (p-value=0.038) and this significant reduction in favour to group A (Table 1).

Table (1): Mean ±SD and p values of absolute proprioception error at 30° knee flexion pre and post-test at both groups

Absolute proprioception error at 30 of knee flexion (degrees)	Pre test	Post test	% of change	p- value
	Mean± SD	Mean± SD		
Group A	3.76±1.47	2.33 ±0.95	38.03 ↓	0.0001*
Group B	3.59 ±1.24	2.85 ± 0.52	20.61 ↓	0.018*
p- value	0.697	0.038*		

*Significant level is set at alpha level <0.05 SD: standard deviation p-value: probability value

Absolute proprioception error at 30 degrees knee flexion (post test for injured and uninjured knees)

In group A the mean ± SD values of Absolute proprioception error at 30° knee flexion in post intervention between injured and contralateral intact knees were 2.76±1.17 and 2.33±0.95 respectively. There was no significant reduction (P-value =0.209*) (Table 2).

In the group B the mean ± SD values of Absolute proprioception error at 30° knee flexion in post intervention between injured and contralateral intact knees were 3.55±1.24 and 2.65±0.52 respectively. There was significant difference (P-value =0.005*) in favour to contralateral intact knee (Table 2).

Between groups A and B there was significant difference of Absolute proprioception error at 30° knee flexion in post-intervention (P-value=0.045 and 0.194 respectively). This significant reduction in favour to group A (Table 2).

Table (2):Mean ±SD and p values of absolute proprioception error at 30° knee flexion injured and contralateral intact knees -test at both groups

Absolute proprioception error at 30 of knee flexion (degrees)	Injured knee	Contralateral intact knee	% of change	p- value
	Mean± SD	Mean± SD		
Group A	2.76±1.17	2.33 ±0.95	18.5 ↑	0.209*
Group B	3.55 ±1.24	2.65 ± 0.52	25.4 ↑	0.005*
p- value	0.045	0.194		

*Significant level is set at alpha level <0.05 SD: standard deviation, p-value: probability value

Absolute proprioception error at 45 degrees of knee flexion (pre and post test for injured knee)

In group A the mean ± SD values of Absolute proprioception error at 45° knee flexion in "pre" and "post" intervention were 3.05±1.08 and 2.1 ±1.06 respectively. There was significant reduction at post intervention in compare to pre- intervention (P-value =0.001*) (Table 3).

In the group B the mean ± SD values of Absolute proprioception error at 45° knee flexion in the "pre" and "post" intervention were 3 ±0.95 and 2.43±0.49 respectively. There was a significant difference at post intervention in compare to pre-treatment (P-value =0.066) (Table 3)

Between groups A and B there was no significant difference of Absolute proprioception error at 45° knee flexion in the pre-intervention (P-value=0.898). While there was significant difference in post-intervention (p-value=0.034) and this significant reduction in favour to group A (Table 3).

Table (3): Mean ±SD and p values of absolute proprioception error at 45 degrees of knee flexion pre and post-test at both groups

Absolute Proprioception error at 45 of knee flexion (degrees)	Pre test	Post test	% of change	p- value
	Mean± SD	Mean± SD		
Group A	3.05±1.08	2.1 ± 0.46	↓ 31.14	0.001*
Group B	3 ±0.95	2.43±0.49	↓ 15.88	0.022*
p- value	0.898	0.034*		

*Significant level is set at alpha level <0.05 SD: standard deviation p-value: probability value

Absolute proprioception error at 45 degrees of knee flexion (post test for injured and uninjuried knees)
In group A the mean ± SD values of Absolute proprioception error at 45° knee flexion in post intervention between injured and contralateral intact knees were 2.9±0.95 and 2.33±0.49 respectively. There was significant reduction (P-value =0.022*) in favour to contralateral intact knee (Table 4).

In the group B the mean ± SD values of Absolute proprioception error at 45° knee flexion in post intervention between injured and contralateral intact knees were 3.51±0.90 and 2.1±0.46 respectively. There was significant reduction (P-value =0.001*) in favour to contralateral intact knee (Table 4)

Between groups A and B there was a significant difference of Absolute proprioception error at 45° knee flexion in post-intervention (P-value=0.044 and 0.134 respectively). This significant reduction in favour to group A (Table 4)

Table (4): Mean ±SD and p values of absolute proprioception error at 45 degrees of knee flexion injured and contralateral intact knees --test at both groups

Absolute Proprioception error at 45 of knee flexion (degrees)	Injured knee	Contralateral intact knee	% of change	p- value
	Mean± SD	Mean± SD		
Group A	2.9 ±0.95	2.33±0.49	19.65 ↑	0.022*
Group B	3.51±0.90	2.1 ± 0.46	40.2 ↑	0.001*

p- value	0.044	0.134	

*Significant level is set at alpha level <0.05 SD: standard deviation, p-value: probability value

Lysholm score

In group A the mean ± SD values of Lysholm score in "pre" and "post" intervention were 64.5 ±9.42 and 85.4 ±11.47 respectively. There was significant increase of Lysholm score at post intervention in compare to pre- intervention (P-value =0.001*) (Table 5).

In the group B the mean ± SD values of Lysholm score in the "pre" and "post" intervention were 64.9±10.58 and 80.1±14.37 respectively. There was significant increase of Lysholm score at post treatment in compare to pre-treatment (P-value =0.0001*).

Between groups A and B there was no significant difference of Lysholm score in the pre and post intervention P-value= 0.90 and 0.205 respectively (Table 5).

Table (5): Mean ±SD and p values of Lysholm score pre and post- intervention at both groups.

Lysholm score (scores)	Pre test	Post test	% of change	p- value
	Mean± SD	Mean± SD		
Group A	64.5 ±9.42	85.4 ±11.47	32.4	0.0001*
Group B	64.9±10.58	80.1±14.37	23.4	0.0001*
p- value	0.90	0.205		

*Significant level is set at alpha level <0.05 SD: standard deviation, p-value: probability value

Objective IKDC

Effusion grades

In group A the frequency distribution of the effusion grades in the "pre-intervention" was 10 patients with grade normal (50%), 5 patients with grade nearly normal (25%) and 5 patients with grade abnormal (25%) While in the "post intervention" was 18 patients with grade normal (90%) and 2 patients with grade nearly normal (10%). there was a significant improvement in the grades of effusion with (p = 0.008*) (Table 14).

In the group B the frequency distribution of the grades of effusion in "pre intervention" was 11 patients with grade normal (55%), 4 patients with grade nearly normal (20%) and 5 patients with grade abnormal (25%) While in the "post intervention" was 16 patients with grade normal (80%), 3 patients with grade nearly normal (15%) and 1 patient with grade abnormal (5%). There was no significant difference in the grades of effusion with (p= 0.09) (Table 6).

Between groups A and B there was no significant difference of frequency distribution of the grades of effusion in the pre- and post-intervention (P-value =0.841 and 0.583) respectively (Table 6).

Table (6): Frequency distribution of the effusion grades in patients pre and post treatment for both groups

Effusion grades	Group A				Group B			
Frequency distribution	Normally	Nearly normal	Abnormal	Severely abnormal	Normally	Nearly normal	Abnormal	Severely abnormal
Pre treatment	10(50%)	5(25%)	5(25%)	0(0%)	11(55%)	4(20%)	5(25%)	0(0%)
Post treatment	18(90%)	2(10%)	0(0%)	0(0%)	16(80%)	3(15%)	1(5%)	0(0%)
(within groups)								
Pre Vs. Post	Group A				Group B			
p-value	0.008*				0.09			
(between groups)								
Group A Vs. group B	Pre treatment				Post treatment			
p-value	0.841				0.583			

*Significant at alpha level <0.05.

Lag of knee flexion grades

In group A the frequency distribution of the lag of knee flexion grades in the "pre-intervention" was 3 patients with grade normal (15%), 8 patients with grade nearly normal (40%) and 2 patients with grade abnormal (10%). While in the "post intervention” was 14 patients with grade normal (70%), 4 patients with grade nearly normal (20%) and 2patients with grade abnormal (10%) there was a significant improvement in the grades of knee flexion with (p = 0.002*) (Table 7).

In the group B the frequency distribution of lag of knee flexion grades in "pre intervention " was 4 patients with grade normal (20%), 9 patients with grade nearly normal (45%), 6 patients with grade abnormal (30%) and 1 patient (5%) with grade severely abnormal While in the "post intervention" was 15 patients with grade normal (75%), 2 patients with grade nearly normal (10%) and 3 patients with grade abnormal (15%). There was a significant improvement in lag of knee flexion grades with (p = 0.003*) (Table 7).

Between groups A and B there was no significant difference of lag of knee flexion grades in the pre- and post-intervention (P-value =0.351and 0.836) respectively (Table 7).

Table (7):Frequency distribution of the Lag of knee flexion grades

Lag of knee flexion grades	Group A				Group B			
Frequency distribution	Normally	Nearly normal	Abnormal	Severely abnormal	Normally	Nearly normal	Abnormal	Severely abnormal
Pre treatment	3(15%)	7(35%)	8(40%)	2(10%)	4(20%)	9(45%)	6(30%)	1(5%)
Post treatment	14(70%)	4(20%)	2(10%)	0(0%)	15(75%)	2(10%)	3(15%)	0(0%)
(within groups)								
Pre Vs. Post					p-value			
Group A					0.002*			
Group B					0.003*			
(between groups)								
Group A Vs. group B	Pre treatment				Post treatment			
p-value	0.351				0.836			

*Significant at alpha level <0.05.

Lag of knee extension grades

In group A the frequency distribution of the lag of knee extension grades in the "pre-intervention " was 2 patients with grade normal (10%), 7 patients with grade nearly normal (35%)and 11 patients with grade abnormal (55%) While in the "post intervention" was 13 patients with grade normal (65%) and 7 patients with grade nearly normal (35%). There was a significant improvement in the grades of knee extension with (p = 0.001*) (Table 8).

In the group B the frequency distribution of lag of knee extension grades in "pre intervention " was 10 patients with grade nearly normal (50%), 9 patients with grade abnormal (45%) and 1 patient (5%) with grade severely abnormal. While in the "post intervention" was 11 patients with grade normal (55%), 7 patients with grade nearly normal (35%) and 2 patients with grade abnormal (10%). There was a significant improvement in lag of knee extension grades with (p = 0.001*) (Table 8). Between groups A and B there was no significant difference of lag of knee extension grades in the pre- and post-intervention (P-value =0.868 and 0.396) respectively (Table 8).

Table (8): Frequency distribution of the Lag of knee extension grades

Lag of knee extension grades	Group A				Group B			
Frequency distribution	Normally	Nearly normal	Abnormal	Severely abnormal	Normally	Nearly normal	Abnormal	Severely abnormal

Pre treatment	2(10%)	7(35%)	11(55%)	0(0%)	0 (0%)	10(50%)	9(45%)	1(5%)
Post treatment	13(65%)	7(35%)	0(0%)	0(0%)	11(55%)	7(35%)	2(10%)	0(0%)
(within groups)								
Pre Vs. Post	Group A				Group B			
p-value	0.001*				0.001*			
(between groups)								
Group A Vs. group B	Pre treatment				Post treatment			
p-value	0.868				0.396			

*Significant at alpha level <0.05.

Lachman test at 25 degree knee flexion grades

In group A the frequency distribution of the Lachman test at 25 ° knee flexion grades in the "pre-intervention " was 3 patients with grade nearly normal (15%)and 10 patients with grade abnormal (50%) and 7 patients severely abnormal (35%) While in the "post intervention" was 11 patients with grade normal (55%), 6 patients with grade nearly normal (30%) and 3 patients with grade abnormal (15%) there was significant improvement in the grades of Lachman test at 25 ° knee flexion (p = 0.0001*) (Table 9)

In the group B the frequency distribution of the Lachman test at 25° knee flexion grades in the "pre-intervention" was 11 patients with grade abnormal (55%) while in the "post intervention" was 7 patients with grade normal (35%), 9 patients with grade nearly normal (45%) and 3 patients with grade abnormal (15%) and 1 patient with grade severely abnormal (5%). There was a significant improvement in the grades of Lachman test at 25 ° knee flexion (p= 0.0001*) (Table 9).

Between groups A and B there was no significant difference Lachman test at 25° knee flexion grades in the pre- and post-intervention (P-value =0.484 and 0.241 respectively (Table 9).

Table (9): Frequency distribution of the Lachman test at 25 degree knee flexion grades

Lachman test at 25 degree knee flexion grades	Group A				Group B			
Frequency distribution	Normally	Nearly normal	Abnormal	Severely abnormal	Normally	Nearly normal	Abnormal	Severely abnormal
Pre treatment	0(0%)	3(15%)	10(50%)	7(35%)	0(0%)	4(20%)	11(55%)	5(25%)
Post treatment	11(55%)	6(30%)	3(15%)	0(0%)	7(35%)	9(45%)	3(15%)	1(5%)
(within groups)								
Pre Vs. Post	Group A				Group B			

p-value	0.0001*	0.0001*
(between groups)		
Group A Vs. group B	Pre treatment	Post treatment
p-value	0.484	0.241

*Significant at alpha level <0.05.

Discussion

The ACL functions both as an anterior stabilizer and as a sensory organ. It is not only provides proprioceptive function, but also initiates protective and stabilizing muscular reflexes. Most ACLs are ruptured in the proximal half and most mechanoreceptors have been reported to be located in the sub-synovial layer near the tibial insertion of the ACL[14-17]. Theory suggests that remnant-preservation allows native tissue to grow into the graft. Particular interest is in whether the synovium, blood vessels, and neural elements, of the remnant, have a positive effect on graft integration and function. The peripheral distribution of the MRCs (in the subsynovial layer) suggests that reconstruction, through the center of the remnant, may preserve these receptors. Other proposed advantages include the creation of a watertight seal (preventing tibial tunnel widening) and more accurate graft positioning [18-19]. Downsides of this method are argued in terms of an increased risk of impingement and cyclops lesions[20-21].

Lei Hong et al[17] reported that the clinical lysholm score between the two tested groups reveled that there was no significant difference with P value = 0.07. Qiang zhang et al[22] reported case series of 62 patients in two groups (Tibial remnant preservation and non tibial preservation) reported that clinical lysholm score between two tested groups reveled that there was no significant difference P value <0.05.

Timo Järvelä [23] reported case series of 65 patients in two groups reported that clinical lysholm score final score 16, there was no significant difference between the groups at 14 months follow up. However, according to these scores, both group were evaluated significantly better at the follow up P value <0.0001. Also,Timo Järvelä [23] reported case series of 65 patients in two groups reported that clinical IKDC final score 11, there was no significant difference between the groups at 14 months follow up. However, according to these scores, both group were evaluated significantly better at the follow up P value =0.075.

In a study by Sun et al. [24] the preserved remnant has significantly enhanced the graft collagen fibers re-cellularization and reorientation, based on these findings, they recommended this technique in ACL reconstruction surgery. This research finding is in disagreement with Hong et al[25] who found that the graft of both techniques of surgery have good synovial coverage with no significant difference in between, which means good graft implant integration and consequently good clinical results. In another study by Gohil et al. [26] and inspite of the improvement of vascularization in the remnant preservation group, no clinical difference were found between both techniques of surgery Regarding knee stability, the current results also come in disagreement with Tie et al. [27] and Mohtadi et al.[28], as they reported no significant differences between the two techniques regarding arthrometry, Lachman and pivot shift test denoting no difference in stability or graft strength.

Regarding the size of the remnant part. Lee et al.[29] reported better outcomes in the group with more than 20% of the native ACL preserved remnant as compared to those with 20% less remnant. Ahn et al. [30] described a remnant preservation and tensioning technique and reported favorable clinical outcomes by evaluating knee stability, second-look arthroscopy, and postoperative magnetic resonance imaging (MRI) Denti et al.[31] observed that after the ACL completely ruptured, mechanoreceptors could exist for 3 months and then gradually disappear over time. However, Georgoulis et al. [32] reported that mechanoreceptors could still be found even 3 years after injury in patients with an ACL remnant adapted to the PCL.

Ahn et al.[184 33] believed that early reconstruction would facilitate preserving more remnant tissue and mechanoreceptors and thereafter assumed to yield good clinical results. Adachi et al. [34] confirmed favorable remodeling of the graft covered with synovium in 12 patients who underwent second-look arthroscopy (40 patients in the study group). They believed that as the remnant was preserved, a portion of blood vessels from the tibial attachment were also preserved, which had a good influence on revascularization of the graft. Takazawa et al. [35] in a nonrandomized study of 218 patients, showed that remnant-preservation resulted in a lower re-rupture rate with better function and stability. However, it should be noted that there was a large difference in the interval from injury to reconstruction between the two groups (7.3 versus 16.3 months)[192].

Kim et al. (66 patients) found statistically significant increases in graft hypertrophy and synovialization, on second-look arthroscopy, combined with increases in clinical outcomes (IKDC and Lysholm scores) in the remnant-preservation group[36]. Lee et al.[29] reported that patients with a remnant more than 20% of its length had better proprioceptive results than those with less than 20% regarding the threshold to detection of passive motion at 30of knee flexion and reproduction of passive positioning at 15and 30. In the present study, for the passive angle reproduction test, we set up the joint position at 15degree of flexion and had the knee joints moved from 90 in the direction of extension, which has been shown to be significantly more sensitive[37]. However, there was no significant difference between the 2 groups, which is inconsistent with the results of Adachi et al.[34] and Lee et al.[29] . One of the possible reasons for the discrepancy between the results may be the difference between allografts and autografts.

Contrary to this, two prospective studies have found no improvement with remnant-preservation. First, Park et al found no difference in functional outcome (IKDC and Tegner scores), range of motion, or stability testing in a study of 100 patients (55 patients underwent remnant-preservation).[38] Second, a randomized controlled trial (RCT), by Hong et al, with 2-year follow-up following a hamstring allograft ACLR, found no ifferences in short-term stability, synovial coverage, or proprioception [39].The mean time from injury to reconstruction, in both of these studies, was 9–11months [38,39]. No studies reported an increased risk of cyclops lesion or loss of motion. Thus, overall, it was concluded that remnant-preservation is at least equivalent to non preservation techniques while clear superiority could not be demonstrated [40-41]. A recent meta-analysis included six RCTs (performed up to 2012) with 378 patients.73 The authors found no difference in terms of stability (KT-arthrometer, Pivot-shift grading, Lachman grading) or function (IKDC or Lysholm score)[42]. However, this meta-analysis confirmed the findings of individual studies with less tibial enlargement and no increase in the incidence of cyclops lesions (or limit to extension)[42-43].

Strengths and Limitations of This study had the following strengths:

- Prospective, randomized controlled study
- Comprehensive assessment, including subjective score, stability, and proprioception was conducted.

The limitations of the study included the following:

- The method for randomization was not perfect.
- The method for proprioception measurement was simple.
- The follow-up period was relatively short.
- The sample size of this study did not fulfill the demand for statistical calculation.

Further studies are needed considering more sample number and long term effects. Further studies are also recommended comparing the different outcomes regarding different percentage of remnant preserving and various graft procedures.

Conclusion

Proprioceptive assessment after arthroscopic ACL reconstruction is effective in improving function, and sense of position, regarding of stump preservation. Short term results were only reported and long term functional effects of the remnant-preserving technique still require to be investigated.

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