|| ISSN(online): 2589-8698 || ISSN(print): 2589-868X ||
International Journal of Medical and Biomedical Studies
Available Online at www.ijmbs.info
PubMed (National Library of Medicine ID: 101738825)
Index Copernicus Value 2018: 75.71
Original Research Article
Volume 3, Issue 6; June: 2019; Page No. 185-192

DIFFERENT METHODS OF FIXATION OF SEMITENDINOSUS GRAFTS IN ARTHROSCOPIC RECONSTRUCTION OF ANTERIOR CRUCIATE LIGAMENT

Rajiv Roy[1], Alok Sobhan Datta[2], Mritunjoy Roy[3]
[1]Assistant Professor, Department of Orthopaedics, North Bengal Medical College and Hospital.
[2]Associate Professor, Department of Orthopaedics, North Bengal Medical College and Hospital.
[3]Post Graduate Trainee, Department of Orthopaedics, North Bengal Medical College and Hospital.

Article Info: Received 02 May 2019; Accepted 18 June. 2019
DOI: https://doi.org/10.32553/ijmbs.v3i6.330
Address for Correspondence: Dr. Alok Sobhan Datta, Associate Professor, Department of Orthopaedics, Institute of Postgraduate Medical Education and Research, Kolkata.
Conflict of interest: No conflict of interest.

Abstract

BACKGROUND: The Anterior Cruciate Ligament (ACL) is the most commonly injured ligament in the human body. Earlier treatment of ACL injury was mainly restricted to sportsmen, but has increased over the years because of awareness and accessibility to treatment facilities. Arthroscopic reconstruction is now the gold-standard for the treatment of ACL tear.

MATERIALS AND METHODS: This study was conducted at IPGME & R, Kolkata in the department of Orthopaedics, where forty patients with single knee injury were taken into consideration, the injury being more than two months old, in the age group 20-50 years, with clinically significant knee instabilities and confirmed on MR imaging.

RESULTS: This was a prospective randomised study where 95% of the patients were male. The outcome was based on regaining pre-injury status and recovery was based on pre- and post-operative clinical and radiological findings and marked according to Tegner- Lysholm scale.

CONCLUSION: Clinical and radiological (MRI) proved knee instabilities due to standardised Anterior Cruciate Ligament injury were best treated by arthroscopic repair using semi-tendinosus graft, which provided to be the gold-standard treatment protocol.

Keywords: ACL Injury, Knee Instability, Arthroscopic Repair, Semitendinosus Graft.

Introduction

Anterior cruciate ligament is most commonly injured ligament, which provides stability to the knee. Previously the concern regarding ACL injury was largely restricted mainly amongst the sportsmen as they required a stable knee most, but now-a-days there is a change in this trend, due to increased awareness of people and easier availability of facilities.

Arthroscopic reconstruction with tendon graft is now the gold standard for the treatment of ACL tear. Among the different graft materials, autologous semitendinosus graft is most popular.

This study deals with the results of different methods of fixation in arthroscopic ACL reconstruction using semitendinosus graft.

This work concerns only about semitendinosus graft (Single bundle). The graft was fixed with tibial tunnel in one end and with femoral tunnel on the other end. The method of fixation was any one of the following:

1. Titanium screw in both femoral and tibial tunnel.
2. Bio-absorbable screw in both femoral and tibial tunnel
3. Endobutton-Mersilene tape for femoral tunnel and bio-absorbable screw for tibial tunnel.

In our study, we evaluated the results of different fixation methods used to fix the semitendinosus graft in arthroscope assisted anterior cruciate ligament reconstruction. Of all the ligaments providing stability to the knee join, ACL is most commonly injured.

The anterior cruciate ligament is the primary restraint to the anterior tibial displacement, accounting for approximately 85% of the resistance to the anterior

drawer test when the knee is at 90 degrees of flexion and neutral rotation. Selective sectioning of the anterior cruciate ligament has shown that the antero-medial band is tight in flexion, providing the primary restraint, whereas the posterolateral bulky portion of this ligament is tight in extension.

The posterolateral bundle provides the principal resistance to hyperextension. Tension in the anterior cruciate ligament is least at 30 to 40 degrees of knee flexion. The anterior cruciate ligament also functions as a secondary restraint on tibial rotation and varus-valgus angulation at full extension.

Investigators have studied the biomechanical properties of anterior cruciate ligament. Noyes, in a comprehensive biomechanical study, determined the ultimate load to be 1725±269N; the stiffness,182±33 N/mm; and the energy absorbed to failure,12.8±2.2 N-m. Woo et al., in younger specimens, found the ultimate load to be 2160±157 N and the stiffness 242±28 N/mm.

Most of the ACL injuries often occur during sports. The injury can happen following a sudden force acting on a straight or slightly flexed knee while the foot is firmly placed on the ground, when changing directions rapidly, sudden deceleration when running, or landing from a jump. This type of injury is common in soccer, skiing, hockey, polo, rugby and other sports with lots of stop-and-go movements and lots of body contact, jumping, or weaving. Falling off a ladder or missing a step on a staircase are other likely causes. The classic history of an anterior cruciate ligament injury begins with a noncontact deceleration, jumping, or cutting action.

An ACL injury can cause small or medium tears of the ligament, a complete tear of the ligament (Rupture), a separation(avulsion) of the ligament from the tibia or femur, or a separation of the ligament and part of the bone from the rest of the bone (Avulsion fracture). When any of these occur, the tibia translates abnormally forward under the femur, with a sense of the knee giving out or buckling.

The prognosis for a torn ACL after conservative management is often unfavourable, with the recovery and rehabilitation period usually very long. Even patients with partial ACL tears may have instability following conservative management. After a complete ACL tear, some patients are unable to participate in cutting or pivoting-type sports, while others have instability even during normal activities, such as walking.

With the increasing trend of diagnosed ACL injury in our day to day life and the demand for returning to one's normal activity as early as possible, surgical treatment for torn ACL has become the standard protocol.

Messner K, Maletius W. Eighteen- to Twenty-Five-Year Follow-up After Acute Partial Anterior Cruciate Ligament Rupture. Am J Sports Med 1999;27(4):455-459. Anterior cruciate ligament due to its poor potential of intrinsic repair Maletius W, Messner K. Eighteen- to Twenty-Four-Year Follow-up After Complete Rupture of the Anterior Cruciate Ligament. Am J Sports Med 1999;27Clancy WG, Ray JM, Zoltan DJ. Acute tears of anterior cruciate ligament. Surgical versus conservative treatment. J Bone Joint Surg [Am] 1988;70:1483- 1488. Andersson C, Odensten M, Good L, et al. Surgical or non-surgical treatment of acute rupture of the anterior cruciate ligament. A randomized study with long-term follow-up. J Bone Joint Surg [Am] 1989; 71:965-974...Aho AJ, Lehto MUK, Kujala UM. Repair of the anterior cruciate ligament: Augmentation versus conventional suture of fresh rupture. Acta Orthop Scand 1986; 57:345-3Kaplan N, Wickiewicz T, Warren R. Primary surgical treatment of anterior cruciate ligament ruptures. A long-term follow-up study. Am J Sports Med 1990;18(4):354-358.is generally replaced by a substitute graft made of tendon. Commonly used grafts are; bone patellar tendon bearing graft and semitendinosus-gracilis graft. In this study only semitendinosus graft is used. Arthroscopic reconstruction of ACL with muscle tendon graft or bone-tendon-bone graft is the gold standard treatment for ACL tear.

Various options, namely bio-absorbable screws, titanium screws, Endobutton-suture wheel, Endobutton-Mersilene tape are available for fixation of the graft. Graft fixation is the crucial step because without proper fixation stability cannot be offered to the knee. Again there is no clear-cut demarcation about which fixation method is best.

MATERIALS AND METHODS

This study was conducted in the Department of Orthopaedics, Institute of Post Graduate Medical Education & Research and S.S.K.M. Hospital, Kolkata-20, from December 2011 to October 2013. In this

prospective randomised study, 40 patients (40 knees) were taken into consideration.

Study population

Patients attending Orthopaedics OPD of IPGME&R, SSKM Hospital with isolated traumatic ACL tears of more than 2 months duration, in the age group 20-50years of age, symptomatic knee instability, positive Pivot shift test, Lachman test and confirmed by MRI findings.

Inclusion Criteria

- Isolated, traumatic ACL tear.
- More than 2 months duration.
- Symptomatic knee instability.
- 20-50 years of age.
- Positive Pivot-shift test.
- Positive Lachman test.
- MRI finding suggesting ACL tear.

Exclusion Criteria

- Non traumatic ACL tear.
- ACL tears lesser 2 month duration.
- Less than 20 years or more than50 years of age.
- Non demanding patient.
- ACL tear associated with other ligament injuries.

Outcomes were defined on the basis of regaining pre

Injury status of the knee in respect of movement, stability of the knee, reduction in pain, swelling and returning to one's normal activity level. Outcome evaluation was done by preoperative and postoperative clinical and radiological findings, and Tegner-Lysholm score.

RESULTS

In this prospective randomised study, 40 patients (40 knees) were taken into consideration. Among them 38 (95%) were males and 2 were females (5%). All the patients were followed up at least for six months. Outcomes defined on the basis of regaining pre injury status of the knee in respect of movement, stability of the knee, reduction in pain, swelling and returning to one's normal activity level. Outcome evaluation was done by preoperative and postoperative clinical and radiological findings, Tegner-Lysholm score.

The above table shows that majority of the patients were male (95%). Among the affected males mostly were from age group 20-29 years, and among the affected females majority were from age group 40-50 years. The average age of affected

AGE	Male	Female
20-29 years	25	0
30-39 years	10	0
40-50 years	3	2
Total	38	2

Table 1: Variation of age & Sex

Method of Fixation	Number of patients	Percentage
Titanium screw for both femoral and tibial tunnel(Group-I)	10	25%
Bio-screw for both femoral and tibial tunnel(Group-II)	10	25%
Bio-screw for Tibial tunnel and Endobutton-Mersilene loop for femoral tunnel (Group-III)	20	50%

Table 2: Distribution of patients according to the method of fixation

Interval	2-6 month	7-12 month	13-22 month
Male	25	10	3
Female	0	1	1
Total	25	11	4
Percentage	62.5	27.5	10

Table 3: Interval between the injury and the procedure

The above table shows that most of the cases (25, 62.5%) were operated within 2-6 months,27.5% cases operated within 7-12months, only 4 cases(10%) were operated after 12 months.

Time period in months	Male	Female	Total	Percentage
0-6 months	2	2	4	10 %
7-12 months	6	0	6	15%
13-22 months	30	0	30	75%

Table 4: Duration of follow up

The above table shows that more than 75% patients were followed up for 13-22 months, 15% patients were followed up for 7-12 months and only 10% patient were followed up for 6 months.

Complications	Male	Female
Superficial infection	3	0
Deep infection	0	0
Tunnel blow out	0	0
Recurrent knee effusion	2	0
Iatrogenic neurovascular injury	0	0
Repeat operation for fixation failure	0	0

Table 5: Incidence of complications

The table shows incidence of complications. Superficial infection occurred in 3 patients. Recurrent episodes of effusion occurred in 2 patients.

Sl. No.	Age	Sex	Lysholm Knee Score		
			At Presentation	1 Month	6 Months
1	20	M	62	72	90
2	22	M	60	74	100
3	20	M	72	90	100
4	20	M	74	84	95
5	24	M	57	69	84
6	23	M	63	76	85
7	25	M	66	78	86
8	27	M	69	80	88
9	27	M	72	80	90
10	27	M	75	82	87
11	26	M	63	85	94
12	28	M	76	85	95
13	29	M	78	82	90
14	28	M	80	100	100
15	27	M	78	90	94
16	25	M	82	94	94
17	25	M	80	90	96
18	22	M	70	78	94
19	21	M	74	96	96
20	21	M	85	90	94
21	24	M	90	95	95
22	29	M	80	100	100
23	28	M	64	85	95
24	28	M	60	84	100
25	21	M	57	76	90
SL. No.	Age	Sex	Lysholm Knee Score		
			At Presentation	1 Month	6 Months
26	30	M	56	78	96
27	30	M	60	80	96
28	32	M	63	75	95
29	34	M	64	76	90
30	34	M	68	80	96
31	35	M	70	85	100
32	37	M	65	80	100
33	39	M	60	82	100
34	38	M	57	84	95
35	38	M	58	85	100
36	40	F	68	95	100
37	43	F	72	96	96
38	46	M	56	88	88
39	48	M	60	78	80
40	50	M	63	100	100
Average score			68.1	74.4	94.1

Table 6: Lysholm knee score of the patients at the time of presentation, at 1month and at 6month postoperative follow-up

The table shows that average Lysholm score of the patients at the time of presentation was 68.1. At 1 month postoperative follow-up the average score was 74.4 and at 6month postoperative follow-up the average score was 94.1 Evaluation of results of different methods of fixation in arthroscopic ACL reconstruction using semitendinosus graft: Statistical analysis.

Software Used

- Statistica version 6 [Tulsa, Oklahoma: StatSoft Inc., 2001]
- GraphPad Prism version 5 [San Diego, California: GraphPad Software Inc., 2007]

Descriptive statistics of numerical variables - Group 1 [n = 10]

	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Std.Dev.	Standard Error
Age	10	23.4	22.0	20.0	29	20.0	27.0	3.57	1.13
InjOpInt	10	6.6	5.5	3.0	12	5.0	9.0	2.80	0.88
DurnFU	10	22.3	22.5	18.0	22	21.0	24.0	1.95	0.62
LKS_B	10	69.4	72.0	57.0	82	62.0	74.0	8.34	2.64
LKS_1m	10	83.4	83.0	72.0	96	76.0	90.0	7.95	2.51
LKS_6m	10	93.0	92.0	85.0	100	90.0	96.0	4.85	1.53

All numerical variables listed above are normally distributed by Kolmogorov-Smirnoff goodness-of-fit test.

Descriptive statistics of numerical variables - Group 2 [n = 10]

	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Std.Dev.	Standard Error
Age	10	27.5	27.0	21.0	37	22.0	30.0	5.34	1.69
InjOpInt	10	5.9	5.5	2.0	11	4.0	7.0	2.92	0.92
DurnFU	10	16.6	18.0	9.0	21	15.0	18.0	3.53	1.12
LKS_B	10	68.7	66.5	56.0	85	60.0	80.0	9.90	3.13
LKS_1m	10	83.5	80.0	74.0	100	78.0	90.0	7.79	2.46
LKS_6m	10	96.0	96.0	94.0	100	94.0	96.0	2.31	0.73

Descriptive statistics of numerical variables - Group 3 [n = 20]

	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Std. Dev.	Standard Error
Age	20	34.1	33.0	24.0	50	27.0	39.5	8.27	1.85
InjOpInt	20	8.3	6.0	2.0	24	4.0	9.5	6.74	1.51
DurnFU	20	13.6	14.5	6.0	22	7.5	18.0	5.88	1.31
LKS_B	20	67.3	65.0	56.0	90	60.0	73.5	9.04	2.02
LKS_1m	20	85.4	85.0	69.0	100	79.0	92.5	8.52	1.91
LKS_6m	20	93.0	95.0	80.0	100	88.0	96.0	5.77	1.29

Comparison of numerical variables between Groups T and P - One-way ANOVA

	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	Fp
Age	832.2750	2	416.1375	1670.700	37	45.15405	9.21595
	0.001						
InjOpInt	42.4500	2	21.2250	1011.050	37	27.32568	0.77674
	0.467						
DurnFU	504.6750	2	252.3375	803.300	37	21.71081	11.62267
	0.000						
LKS_B	33.0750	2	16.5375	3060.700	37	82.72162	0.19992
	0.820						
LKS_1m	38.0750	2	19.0375	2495.700	37	67.45135	0.28224
	0.756						
LKS_6m	69.0250	2	34.5125	892.950	37	24.13378	1.43005
	0.252						

Thus there is significant difference between groups in Age and Duration of FU, but not in other parameters compared.

Comparison of change over time in Group 1

Repeated measures ANOVA followed by Tukey's test for multiple comparison if ANOVA returns p value < 0.05

LKS

Repeated measures ANOVA No. of datasets 3 F value 54.066 p value < 0.001

Tukey's Multiple Comparison Test	Mean Diff.	q	P value	95% CI of diff
LKS_B vs LKS_1m	-14.000	8.6738	< 0.001	-19.825 to -8.1749
LKS_B vs LKS_6m	-23.600	14.622	< 0.001	-29.425 to -17.775
LKS_1m vs LKS_6m	-9.6000	5.9477	< 0.01	-15.425 to -3.7749

Comparison of change over time in Group 2

Repeated measures ANOVA followed by Tukey's test for multiple comparison if ANOVA returns p value <0.05

LKS

Repeated measures ANOVA No. of datasets 3 F value 55.775 p value < 0.001

Tukey's Multiple Comparison Test	Mean Diff.	q	P value	95% CI of diff
LKS_B vs LKS_1m	-14.800	8.0879	< 0.001	-21.404 to -8.1959
LKS_B vs LKS_6m	-27.300	14.919	< 0.001	-33.904 to -20.696
LKS_1m vs LKS_6m	-12.500	6.8310	< 0.001	-19.104 to -5.8959

Comparison of change over time in Group 3

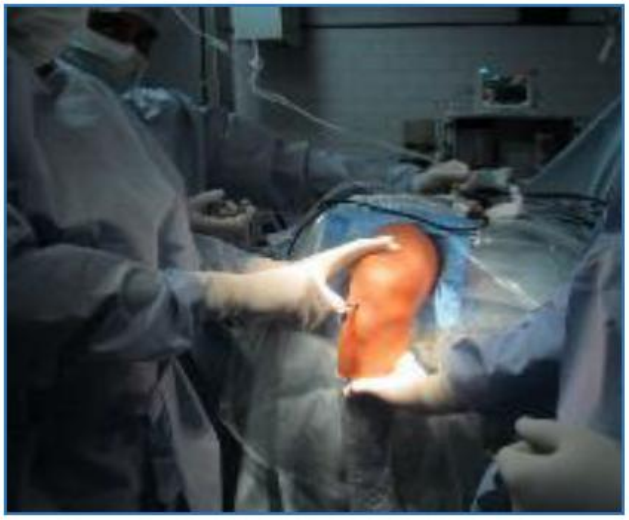
Repeated measures ANOVA followed by Tukey's test for multiple comparison if ANOVA returns p value < 0.05

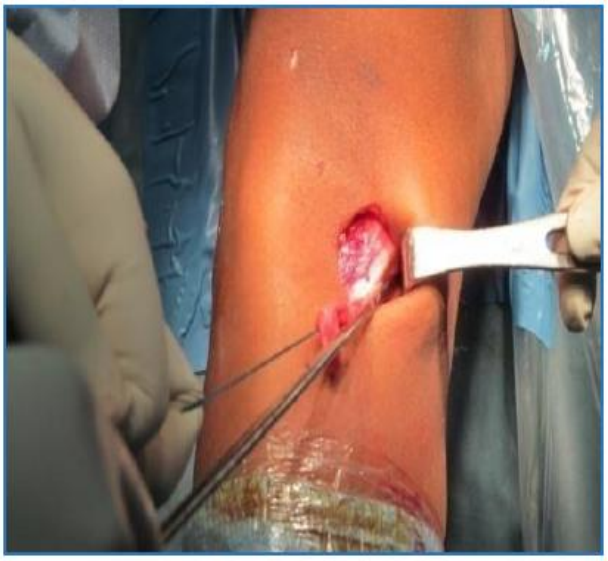
LKS

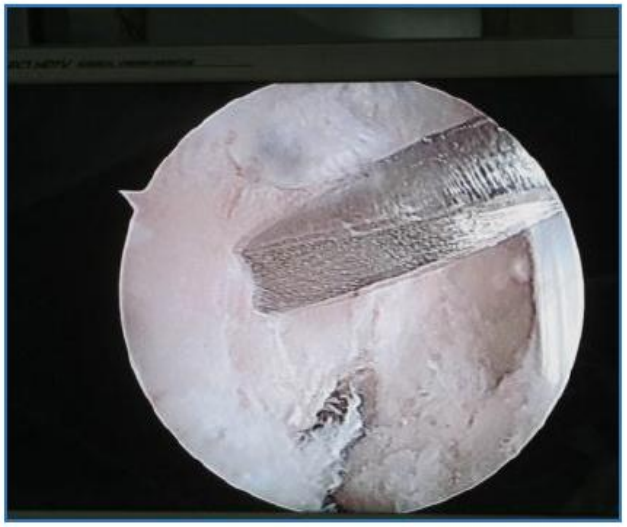
Repeated measures ANOVA No. of datasets 3 F value 99.656 p value < 0.001

Tukey's Multiple Comparison Test	Mean Diff.	q	P value	95% CI of diff
LKS_B vs LKS_1m	-18.100	13.708	< 0.001	-22.657 to -13.543
LKS_B vs LKS_6m	-25.650	19.425	< 0.001	-30.207 to -21.093
LKS_1m vs LKS_6m	-7.5500	5.7178	< 0.001	-12.107 to -2.9934

Evaluating the results of different methods of fixation, no statistically significant difference was found regarding outcome







DISCUSSION

Anterior cruciate ligament is the most commonly injured ligament which provides stability to the knee. Earlier, ACL reconstruction was done by open methods but with time this went out of favour due to various drawbacks like risk of infection, long term hospital stay, joint stiffness, loss of working days, prolonged rehabilitation, and advent of arthroscopy.

Arthroscopic reconstruction with tendon graft is now the gold standard for the treatment of ACL tear. Among the different graft materials autologous semitendinosus graft is preferred.(1) The method of fixation of the graft is of primary importance as it is the weakest link and mainly responsible for complications. Without proper fixation the graft cannot withstand the stress generated to keep the knee stable. This study dealt with the results of different methods of fixation in arthroscopic ACL reconstruction using semitendinosus graft.

Selection of 40 patients by proper clinical and radiological evaluation was based on the inclusion criteria. Among them 38 patients (95%) were male, 2 patients (5%) were female. Among the affected males, most were from the age group 20-29 years, and among the affected females majority were from age group 40-50 years. The average age of affected males was 29.1 years and females were 41.5 years. The male: female ratio was 19: 1.

Most of the cases (25, 62.5%) were operated within 2-6 months, 27.5% cases were operated within 7-12months, only 4 cases (10%) were operated after 12 months.

Patients were divided in three groups according to the method of fixation chosen. Endobutton-Mersilene tape/loop for femoral tunnel and Bioscrew for tibial tunnel was chosen as fixation method for 20 (50%) patients(group-III),Titanium screw for both the tunnels was chosen as fixation method for 10(25%) patients (group-I), Bioscrew for both tunnels chosen as fixation method for another 10(25%) patients(group-II).

In our study more than 75% patients were followed up for 13-22 months, 15% patients were followed up for 7-12 months and only 10% patient were followed up for 6 months.

The average Lysholm score of the patients at the time of presentation preoperatively was 68.1. At 1 month postoperative follow-up the average score was 74.4 and at 6month postoperative follow-up the average score was 94.1. The average Lysholm score at 6 month postoperative follow-up for Group-I patients was 93.1. The average Lysholm score for Group-II patients at 6 month postoperative follow-up was 93.4. For Group-III patients the Lysholm score at 6 month follow-up was 96.6. For all three Groups the scores were marked excellent. According to Lysholm score the criteria for grading the outcome were:

Poor –a score < 65;

Fair–a score of 65-83;

Good- a score of84-90;

Excellent- a score >90.

Lachman test &Pivot-shift test were negative at 1 month and 6 months follow-up for all the patients.

Complications like superficial infection was noted in 3 patients, recurrent knee effusion occurred in 2 patients. No case of graft fixation failure requiring repeat surgery was noted.

Outcome was measured with preoperative and postoperative clinical evaluation and by the Tenger-Lysholm scoring system .No significant difference was found between the three groups regarding outcome.

Most of the studies showed that there was no significant difference between bioabsorbable fixation material and metallic fixation devices regarding clinical outcome: pain, swelling- with- activity & range of motion. Thus bioabsorbable screw provided a reasonable alternative to titanium screw (5) and the results were comparable.

The serial follow-up study showed significant improvement in outcome in all three groups. The

outcome for individual groups were found to be excellent as also the average Lysholm score.

In our study we evaluated 40 patients. The results could have been more significant had the study population been a larger one with a longer follow up.

SUMMARY AND CONCLUSION

The prognosis for a torn ACL after conservative management is often unfavourable, with the recovery and rehabilitation period usually very long. Even patients with partial ACL tears may have instability after conservative management. Nonoperative treatment is a viable option for those who are willing to make lifestyle changes and avoid activities that cause recurrent instability. [16] Arthroscopic reconstruction with tendon graft is now the standard option for the treatment of ACL tear. Among the different graft materials, autologous semitendinosus graft is a preferred one.

For fixation of the graft, available fixation devices are either bioabsorbable or metallic. Studies done in this field comparing the outcome between bioabsorbable and titanium fixation devices showed no significant differences. (7,8,10,11)

We selected 40 patients by proper clinical and radiological evaluation based on our inclusion criteria. Among them 38 patient (95%) were males and 2 patients (5%) were females. Among the affected males most were from age group 20-29 years, and among the affected females majority were from age group 40-50 years. The average age of affected males was 29.1 years and females were 41.5 years. The male: female ratio was 19:1

In conclusion, this procedure benefitted all the end-users with excellent results.

REFERENCES

1. Luca Capuano, Philippe Hardy, Umile Giuseppe Longo, Vincenzo Denaro, Nicola Maffulli, No difference in clinical results between femoral transfixation and bio-interference screw fixation in hamstring tendon ACL reconstruction-a preliminary study The Knee (2008),Volume: 15, Issue: 3, Pages: 174-179.
2. M Hamada, K Shino, S Horibe, T Mitsuoka, T Miyama, Y Shiozaki, T Mae. Comparison between different femoral fixation devices for ACL reconstruction with doubled hamstring tendon graft-a biomechanical analysis-Arthroscopy-the journal of arthroscopic related surgery official publication of the Arthroscopy Association of North America and the International Arthroscopy Association (2001),Volume: 22, Issue: 6, Pages: 801-807.
3. Anna-Stina Moisala, Timo Järvelä, Antti Paakkala, Timo Paakkala, Pekka Kannus, Markku Järvinen.Comparison of the bioabsorbable and metal screw fixation after ACL reconstruction with a hamstring autograft in MRI and clinical outcome:a prospective randomized study.Knee surgery sports traumatology arthroscopy official journal of the ESSKA (2008) Volume: 16, Issue: 12, Pages: 1080- 1086:
4. Cameron M, Buchgraber A, Paller H et all: The natural history of anterior cruciate ligament deficient knee, changes in synovial fluid cytokine and keratin sulfate concentration, American Journal of Sports medicine,25:751,1997.
5. P Kousa, T L Järvinen, P Kannus, M Järvinen,Initial fixation strength of bioabsorbable and titanium interference screws in anterior cruciate ligament reconstruction, biomechanical evaluation by single cycle and cyclic loading, The American Journal of Sports Medicine (2001),Volume: 29, Issue: 4, Pages: 420-425.
6. Christopher Kaeding, Jack Farr, Tim Kavanaugh, Angela Pedroza, Prospective randomized comparison of bioabsorbable and titanium anterior cruciate ligament interference screws, Arthroscopy Association of North America and the International Arthroscopy Association (2005),Volume: 21, Issue: 2, Pages: 147-151.
7. Caborn DN, Urban WP Jr, Johnson DL, Nyland J, Pienkowski D,A biomechanical comparison between Bioscrew and titanium alloy interference screws for bone-patellar tendon-bone graft fixation in anterior cruciate ligament reconstruction.
8. Lanny L. Johnson, M.D, G.Eda vanDyk, M.D, Department of Surgery, Michigan State University, East Lansing, Michigan, U.S.A, Metal and biodegradable interference screws: Comparison of failure strength,The Journal of Arthroscopic & Related Surgery August 1996, Pages 452–456,Volume 12, Issue 4.
9. F.Alan Barber, M.D., a, Burton F. Elrod, M.D.b, David A. McGuire, M.D.c, Lonnie E. Paulos, M.D.d, Preliminary results of an absorbable interference screw, Arthroscopy: The journal of Arthroscopic & related surgery.

10. David A. McGuire, M.D., F.Alan Barber, M.D., Burton F. Elrod, M.D. Lonnie E. Paulos, M.D.,Bioabsorbable Interference screws for graft fixation in Anterior Cruciate Ligament Reconstruction, Arthroscopy: The Journal of Arthroscopic & Related Surgery,Volume 15, Issue 5, July–August 1999, Pages 463–473.

11. DNM Caborn, M Coen, R Neef †,D Hamilton, J Nyland, DL Johnson,Division of Orthopaedic Surgery, The University of Kentucky School of Medicine, Lexington, USA,Quadrupled semitendinosus-gracilis autograft fixation in the femoral tunnel:a comparison between a metal and a bioabsorbable interference screw, Arthroscopy: The Journal of Arthroscopic & Related Surgery Volume 14, Issue 3, April 1998, Pages 241–245.

12. Mark Walton, Ph.D,Department of Orthopaedic Surgery, Dunedin School of Medicine, University of Otago, Dunedin, New Zealand,Absorbable and Metal Interference Screws:Comparison of graft security during healing,Arthroscopy: The Journal of Arthroscopic & Related Surgery, Volume 15, Issue 8, November–December 1999, Pages 818–826 .

13. Andre Weimann, M.D.a, Mareike Rodieck, M.D.a, Thore Zantop, M.D.a, Joachim Hassenpflug, M.D.a, Wolf Petersen, M.D.b, a Department of Orthopaedic Surgery, Christian-Albrechts University Kiel, Kiel,b Department of Trauma, Hand, and Reconstructive Surgery, Westfälische Wilhelms University Münster, Münster, Germany,Primary stability of hamstring graft fixation with biodegradable suspension versus interference screws,Arthroscopy: The Journal of Arthroscopic & Related Surgery,Volume 21, Issue 3, March 2005, Pages 266–274.

14. Giuseppe Milano, M.D.a, Pier Damiano Mulas, M.D.b, Fabio Ziranu, M.D.b, Stefano Piras, M.D.b, Andrea Manunta, M.D.b, Carlo Fabbriciani, M.D.a,a Department of Orthopaedics, Catholic University, Rome,b Department of Orthopaedics, Sassari, Italy,Comparison Between Different Femoral Fixation Devices for ACL Reconstruction with Doubled Hamstring Tendon Graft:A bomechanical analysis, Arthroscopy: The Journal of Arthroscopic & Related Surgery,Volume 22, Issue 6, June 2006, Pages 660–668.

15. Jon Olav Drogset, M.D.a, Torbjørn Grøntvedt, M.D., Ph.D.a, Vigleik Jessen, M.D.a,Agnar Tegnander, M.D., Ph.D.a, Tom Eirik Mollnes, M.D., Ph.D.b, Kåre Bergh, M.D., Ph.D.c,a Department of Orthopaedics, Trondheim University Hospital, Institute of Immunology, Trondheim, Norway,b Rikshospitalet University Hospital, University of Oslo, Oslo, Norway and Bioabsorbable Screws Used in Anterior Cruciate Ligament,Comparison of In Vitro and In Vivo Complement Activation by Metal Reconstruction

16. Daniel DM, Stone ML, Dobson B.E. et all: Fate of ACL injured patients: a prospective random study, American Journal of Sports medicine, 22:632,1994.