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Prospective study of arthroscopic reconstruction of anterior cruciate ligament with quadrupled semitendinosus autograft

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Abstract

Background: In contrast to old time in today's world of competitive sports and vehicular accidents twisting injuries to knee joints causing ligament and meniscal tears are a common occurrence. Being a prime stabilizer of the knee joint anterior cruciate ligament is truly "crucial" for normal functioning and stability of knee. It is responsible for prevention of forward displacement of tibia on the femur as well as prevention of hyperextension and excessive internal rotation of tibia. Additionally it acts as restraint on valgus and varus stress in all degrees of flexion and fine-tunes the screw home motion as the tibia approaches terminal extension. Rupture of ACL, unless properly reconstructed, can have catastrophic consequences for knee stability. The methods of reconstruction of a ruptured ACL include intra-articular reconstruction, extra-articular reconstruction and combined intra-articular and extra-articular reconstruction. With advances in arthroscopy intra-articular reconstruction is fast becoming procedure of choice due to less morbidity and prospect of an early mobilization. Recent studies have shown that four stranded semitendinosus tendon graft have similar strength and stiffness characteristics as that of normal anterior cruciate ligament. We conducted this study to evaluate the result of arthroscopic reconstruction of anterior cruciate ligament with quadrupled semitendinosus autograft and complications associated with this procedure.

Materials and Methods: After obtaining approval from institutional ethical committee we conducted a prospective study of 30 patients who had been admitted to our institute with pain, limp and instability due to anterior cruciate ligament rupture. Patients were enrolled on the basis of pre-defined inclusion criteria and any patient having any exclusion criteria was excluded from the study. X-Ray and MRI (if required) were done. Detailed history, thorough clinical examination and baseline investigations were done. All patients underwent ACL reconstruction by semitendinosus autograft. The outcome of arthroscopic reconstruction with quadrupled semitendinosus autograft and complications associated with this procedure were studied. The data was tabulated and analyzed using SPSS 16.0 version software.

Results: This study consisted of 30 patients having been diagnosed with anterior cruciate ligament rupture. There were 27 men and 3 women with a M: F ratio of 1: 0.11. The most common age group involved was 31-35 years (30%) followed by 20-25 years (26.67%) and 26-30 years (16.67%). Road traffic accidents (46.67%) and Sports injuries (43.33%) were the predominant causes of ACL rupture. Most patients (26.67%) presented within 6 months of injury. Associated meniscal injuries were seen in 11 (36.67%) patients and medial meniscus (20%) was found to be involved more commonly than lateral meniscus (16.67%). Majority of the patients received 9 mm graft (60%). Most of the patients were discharged from hospital within 1 week (53.33%) while 9 patients (30%) needed to be kept in hospital for up to 2 weeks. Only 5 patients (16.67%) required hospitalization beyond 2 weeks. Pre-operative Tenger- Lysholm score was poor in majority of the patients (73.33%). Post-operatively at the time of 6 months follow up majority of the patients (66.67%) had an excellent Tenger-Lysholm score. No major complications were encountered in any of our patients. Minor complication like wound infection at the graft site (2/30), wound edge necrosis (2/30), foot drop (1/30), chemical burn under the tourniquet (1/30) and synovitis (1/30) were seen in some patients. All these complication resolved with proper management and no residual complications were seen in any of the patients.

Conclusion: Arthroscopic reconstruction of ruptured anterior cruciate ligament by quadrupled semitendinosus autograft is associated with good functional results and excellent outcome. Minor complications associated with the procedure can be taken care of by appropriate management.

Keywords: Anterior cruciate ligament rupture, quadrupled semitendinosus autograft, complications, functional outcome

Introduction

Gone are the days when anterior cruciate ligament (ACL) led a relatively safe existence. It was a time when only a fall from a chariot or a jousting horse sent a gladiator or knight to an early

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retirement because of an unstable knee. But in today's world of vehicular accidents, sports injuries and other traumatic conditions causing twisting injuries to knee has led to an increase in the incidence of anterior cruciate ligament tear [1].

The anterior cruciate ligament is truly a "crucial" ligament of the knee. It is the prime anterior stabilizer of the knee and prevents forward displacement of tibia on the femur. Its secondary functions are prevention of hyperextension and excessive internal rotation of tibia. It also acts as restraint on valgus and varus stress in all degrees of flexion and fine-tunes the screw home motion as the tibia approaches terminal extension [2]. If the anterior cruciate ligament is ruptured, the synchronous rolling and gliding movements of the knee disintegrate and knee becomes susceptible to attrition. The fact that unrepaired anterior cruciate ligament rupture and resultant abnormal force distribution can lead to progressive knee deterioration have led to widespread acceptance of surgical repair of ACL rupture. Sir Arthur Mayo Robson was the first surgeon to carry out ACL repair in a miner who injured his ACL during mining [3]. This initial repair of ACL had paved the way for further advances in surgical repair of ACL and later various grafts like fascia lata, quadriceps tendon and bone-patellar tendon bone (BPTB) graft were used by many surgeons. For many years BPTB graft was the only successful option available for reconstruction of ACL [4]. Friedman M.J was the first surgeon to use quadrupled hamstrings for bicortical screws for fixation for ACL repair but use of bicortical screws for fixation had poor fixation strength and many times resulted in need of revision surgeries. Later improvements in fixation systems such as cortical buttons and interference screws led to re-emergence of quadrupled hamstring grafts for ACL repairs [5]. The advantages with semitendinosus grafts are availability of a greater sectional area and unaffected integrity of the extensor mechanism. Moreover tensile strength of quadrupled hamstring is found to be even better than a normal ACL. Many studies have found that the rate of return to pre-surgical levels of activity was more than 60% after this procedure and the rate of complications like extension loss, anterior knee pain and surgical site infections was also lower than other procedures like in BPTB grafts [6]. Surgical methods of reconstruction of the torn anterior cruciate ligament can be divided into three broad categories namely the intra-articular reconstruction, the extra-articular reconstruction and combined intra-articular and extra-articular reconstruction. With advances in arthroscopy and surgical techniques, intra-articular reconstruction of anterior cruciate ligament is preferred as it is more anatomical, accurate and effective with less morbidity.

Several level II studies were performed on the arthroscopic anterior cruciate ligament reconstruction. It was found that good to excellent results have been noted in 69-95% patients after ACL reconstruction and reconstructed knee was found to have near normal biomechanics [7, 8]. Long term evaluation revealed the complications in the form of persistent instability, persistent pain, re-rupture, impingement, degenerative changes and difficulty in returning to previous activity. Many patients were unable to attain the pre-injury levels of activity [9, 10]. Recent studies have shown four

stranded semitendinosus tendon graft have similar strength and stiffness characteristics as that of normal anterior cruciate ligament.

Hence, a prospective study was undertaken to evaluate the result of arthroscopic reconstruction of anterior cruciate ligament with quadrupled semitendinosus autograft. Complications associated with surgical intervention were also studied.

Materials and Methods

The patients complaining of knee pain, limp during activity and instability due to anterior cruciate ligament rupture were enrolled in this study and were evaluated for their disability. The evaluation of the patients included detailed history taking, noting the exact mechanism of injury, degree of instability and disability i.e. giving way, locking, inability to take part in active sports, recurrent swelling etc. Local examination consisted of examination for rotatory instability and laxity of other ligaments by various tests. Laboratory investigations like CBC, Bleeding time, clotting time, HIV, HBsAg, LFT, KFT, ECG and blood sugar level were done in all the patients before surgical intervention. Radiological work up included X-rays including antero-posterior and lateral views and MRI of knee (if required). Knee scoring was done using Tegner Lysholms knee scoring scale [11].

Surgical Technique

Tendon: Semitendinosus autograft

Sutures: No.2 non- absorbable coated braided polyester green suture. No.5 non- absorbable coated braided polyester green suture. 2-0 absorbable coated polyglactin 910 violet suture.

2-0 non- absorbable monofilament polyamide black suture.

Implant: Endobutton CL/Endobutton with no.5 polyester green, Bioabsorbable screw/cannulated cancellous screw/suture wheel.

Graft harvest and preparation: Semitendinosus harvest is accomplished with the knee in 90 degrees of flexion. A 4 – 5 cm longitudinal incision is made over the pes tendons beginning 2 -3 cm distal to the joint line and 1 cm to 2 cm medial to the tibial tuberosity. The Sartorius aponeurosis is identified and semitendinosus tendon is palpated. The Sartorius aponeurosis is incised in line with its fibers distal to underlying semitendinosus tendon. Using digital palpation, the semitendinosus tendon is isolated where it naturally separates from gracilis tendon, approximately 5 -8 cm proximal to their tibial insertions. A no.2 non-absorbable suture was used to place running whipstitch at five to six levels in distal tendons to control the free end. While traction is applied to the free end of tendon using the whipstitch, the deep fascial bands to the medial gastrocnemius fascia can be identified and released. With the knee flexed 70 -80 degrees, gentle traction is maintained on the distal end while closed end stripper is advanced proximally in line with the tendon. Inspection of superficial part of medial collateral ligament is carried out. The graft was prepared by dividing the tendon into 2 halves and the ends were prepared by whipstitch. The two grafts were then doubled over endobutton.

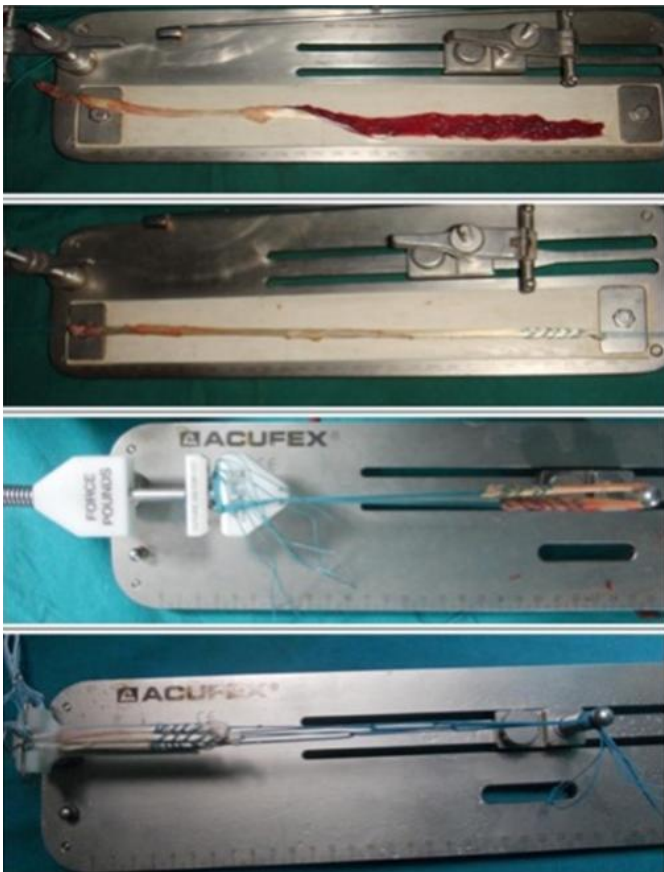


Fig 1: Various steps of semitendinosus graft harvesting and preparation

Endoscopic preparation: The longitudinal anterolateral portal was created 1 cm above the joint line immediately adjacent to patellar tendon and the anteromedial portal is created at the same level above the joint line from 5-8 mm medial to the patellar tendon. If necessary the ligament mucosum and fat pad is excised to facilitate viewing the intercondylar notch. The ACL stump is debrided partially leaving a substantial portion to guide tibial tunnel placement. The intercondylar notch is then evaluated. Notchplasty is performed if needed.

Tibial tunnel preparation: Through the incision taken for graft harvest tibial tunnel is prepared. The endoscopic aimer for the tibial tunnel is adjusted to the 45 degree position and the guide tip is positioned intra-articularly through anteromedial portal. A cannulated reamer corresponding to size of the graft is used to drill tibial tunnel. (Fig 7-6)

Femoral tunnel preparation: The femoral guide pin is then inserted at 11 o'clock position for the right knee and 1 o'clock position for the left knee and advanced 2 -3 cm into femur while maintaining the knee at 90 degrees of flexion. A calibrated, cannulated, endoscopic reamer sized to match the graft's proximal diameter is placed through the tibial tunnel and abutted against the femur. The femoral tunnel is drilled 5-6mm deeper than the graft insertion length to allow for a „turning radius” of the endobutton. A 4.5 mm cannulated reamer is used to over drill this passing pin through the cortex. A depth gauge measures the total femoral channel length precisely.

Graft passage and fixation: Tying the non-absorbable suture at its calculated length completes graft preparation. The no. 5 and no. 2 non absorbable sutures are threaded through the

eyelet of each passing pin and the pin is extracted proximally, bringing the sutures out through distal thigh. The no. 5 suture is used as leading thread. The graft is viewed endoscopically to ensure the graft marker line is even with the entrance of the femoral socket. The trailing no.2 suture is pulled to flip the endobutton external to femoral tunnel. The endobutton is deployed on the cortex of femoral fixation. With manual tension applied the knee is taken through a range of motion to confirm endoscopically the absence of graft impingement. Tibial fixation is done by suture post. A perpendicular hole to anteromedial cortex is drilled with 2.5 mm drill bit in proximal tibia. A self-tapping unicortical cancellous fixation is advanced incompletely. The graft is tensioned at about 30 degree knee flexion and the matched sutures are secured around the fixation screw. Then the screw is tightened fully.

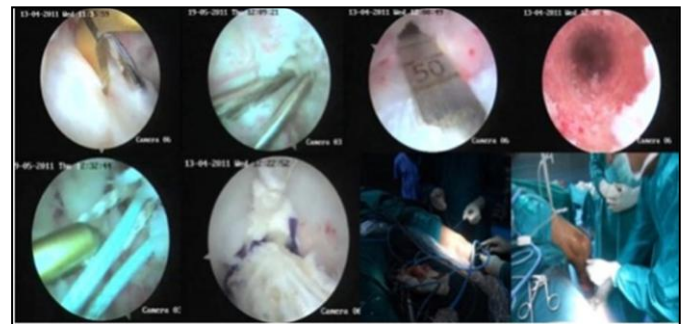


Fig 2: Various Steps of surgery including formation of tibial tunnel, femoral tunnel, endobutton flipping, graft passage and cycling

The data from 30 studied cases was studied using appropriate statistical methods. P <0.05 was taken as statistically significant. Data analysis was carried out using SPSS16.0 version software. Microsoft word and excel were used for generating charts and graphs

Inclusion criteria

1. Patients with anterior cruciate ligament injury.
2. Age: 20 years to 50 years.
3. Patient of either sex.

Exclusion criteria

1. Patients with knee pain due to osteoarthritis.
2. Age :< 20 years and >50 years

Results

The present study was performed to evaluate the results of anterior cruciate ligament reconstruction with quadrupled semitendinosus autograft. Total 30 patients were included in this study out of these 30 patients 23 were males and 7 were females with a M: F ratio of 1: 0.11.

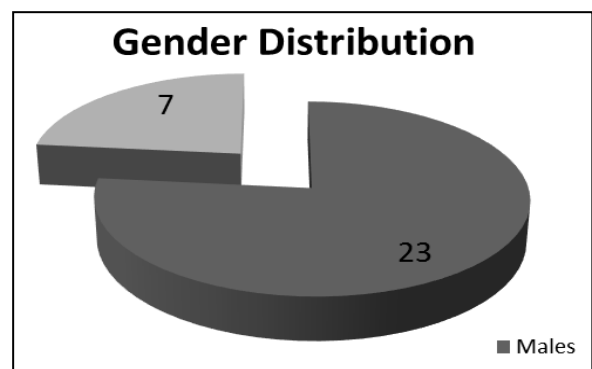


Fig 3: Gender distribution of the studied cases

The analysis of the age groups of the studied cases revealed that the most common affected age group was between 31 to 35 years followed by 20-25 years (26.67%) and 26-30 years (16.67%). The mean age of the patient in this study was found to be 31.53 + 7.247 years.

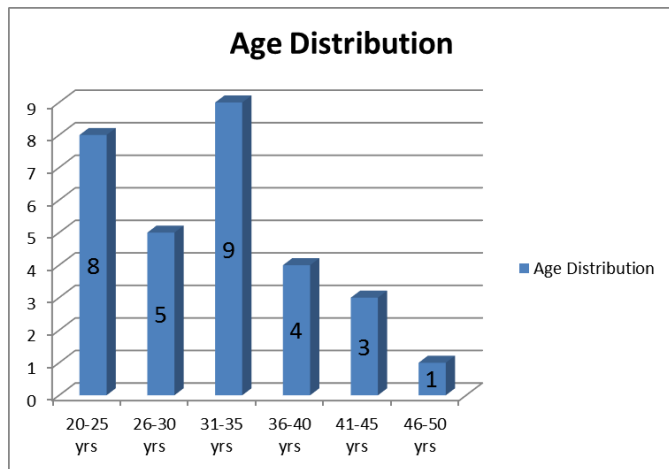


Fig 4: Age distribution of the studied cases

The analysis of mode of injuries revealed that the most common cause of ACL tear was due to road traffic accidents (46.67%) followed by sports injury (43.33%) and household fall (10%).

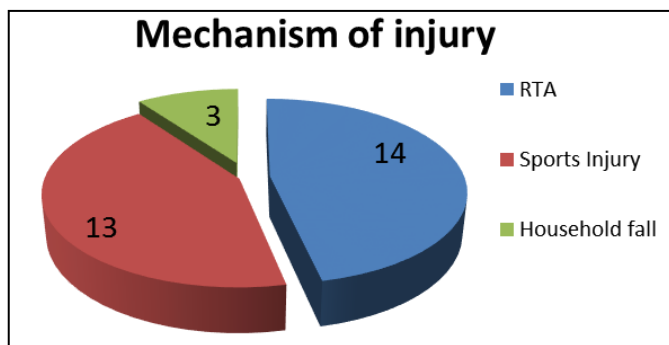


Fig 5: Mechanism of the injury in the studied cases

In our study most of the patients presented within 6 months of injury (26.67%) followed by between 3-4 years (16.67%) and 1-2 years (13.33%). 3 patients (10%) presented more than 4 years after injury.

Table 1: Time period between injury and presentation

Time Since Injury	No of Patients	Percentage
Within 1 Month	1	3.33
1- 6 Months	8	26.67
6 months- 1 year	3	10
1-2 years	4	13.33
2-3 years	6	20
3-4 years	5	16.67
More than 4 years	3	10
Total	30	100

The ACL injuries are many of the times associated with meniscal tears or meniscal injury may occur over a period of time due to faulty weight distribution due to ACL tear. In our study 11 (36.67%) patients were found to be having associated meniscal injuries while 16 (63.33%) patients didn't have any meniscal involvement. Medial meniscus (6/11) was found to be affected more than lateral meniscus (5/11).

Table 2: Incidence of associated meniscal injury in the studied cases

Associated Meniscal Injury	No of Patients		Percentage
	Present	Lateral Meniscus	
	Medial Meniscus	6 (20%)	
Absent	19		63.33%
Total	30		100

The Graft size used consisted of graft of mm, 9 mm and 10mm. 9 mm graft was used in majority (60%) of the patients followed by 10 mm (33.33%) and 8 mm (6.67%) grafts.

Table 3: Various Graft sizes used in the cases

Graft size (mm)	No. of patients	Percentage
8	2	6.67
9	18	60
10	10	33.33

Most of the patients (53.33%) were discharged from the hospital within 7 days of the surgery. 8 to 14 days and more than 2 weeks stay was required in 9 (30%) and 5 (16.67%) patients respectively.

Table 4: Duration of hospital stay in the studied cases

Hospital stay	No. of patients	Percentage
Up to 7 days	16	53.33
8-14 days	9	30
>2 weeks	5	16.67
Total	30	100

Preoperative and postoperative (after 6 months) Tegner Lysholm scores were compared. While preoperatively 22 patients had poor Tegner Lysholm scores postoperatively none had poor Tegner Lysholm scores. Mean preoperative Tegner Lysholm knee score of patients in the present study was 60.5+ 5.8. Postoperatively 66.67% of the patients had excellent, while 26.67% had good and only 6.67 had fair knee score as per Tegner lysholm scoring system. The mean Tegner Lysholm knee score after 6 months of follow up was 91.2+4.2.

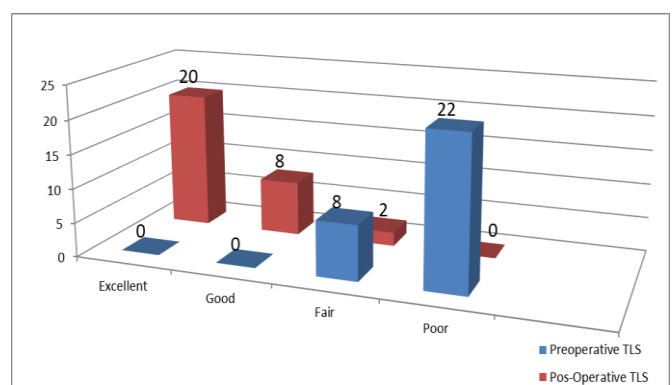


Fig 6: Pre and post-operative Tegner Lysholm scores in the studied cases

Discussion

The cruciate ligaments perform functions of a true gear mechanism preventing the femur from rolling off the posterior side of tibia during flexion by controlling the ratio of rolling and gliding and thus form the nucleus of biomechanics and kinematics of the knee joint. Rupture of cruciate ligament abolishes the gear mechanism which cannot be replaced satisfactorily by the peripheral ligaments and the joint

capsule. Hence these secondary capsuloligamentous restraints are exposed to abnormal forces and get stretched. Over time, with continued tibial subluxation under high loading forces, chondral damage and other meniscal injuries ensue leading ultimately to severe functional disability. Kennedy *et al* compared the long term results of 19 acute tears of the anterior cruciate ligament treated surgically and 31 acute tears not subjected to surgery. A follow up study after seven years showed that the untreated group had deteriorated far more significantly as compared to the treated group, though the short term follow up at 44 months had not shown any significant differences between the two groups. Therefore he recommended repair of all acute anterior cruciate ligament tears to prevent long term sequelae. Reconstruction of anterior cruciate ligament with quadrupled semitendinosus autograft is a popular procedure. The goal of treatment is to return the injured patient to the desired level of function [12].

In present study, selection of cases has been done based on four basic criteria i.e. degree of anterior cruciate ligament laxity, extent of disability, age of the patient and injury to other capsuloligamentous structures of the knee. Only those patients who had laxity as tested by anterior drawer test and who had minimal or no other rotatory instability were considered for study and subjected to surgery. This has been done to eliminate interference of other rotational instabilities in the results of anterior cruciate ligament reconstruction.

Our series comprises 30 cases treated over last two years. We have used Tegner Lysholm knee scoring scale to evaluate the results as this is statistically proven as a better rating system and is widely used.

In our study the mean age of the patients was 31.53±7.24 years. ACL tears are associated with sporting activities as well as motor vehicular accidents hence seen in relatively young individuals. Mean age of the patients appear to be similar to various studies conducted by Leyshon *et al* (33 years), Weiss *et al* (29 years) and Shino *et al* (25 years) [13, 14, 15]. In our studies males were affected predominantly. The fact that in our country men are more likely to be involved in sporting activity and motor vehicular accidents makes them more prone for Internal derangement of the knee like ACL tear, PCL tear or meniscal injuries. Male predominance in ACL injuries was also found in studies conducted by Bruchman *et al* (M: F ratio of 2.3:1) and Shafiqhian *et al* (M: F ratio of 2.3:1). This ratio is slightly less in western world because of increase involvement of females in driving and sports activity [16, 17].

Zairns *et al* did the study of 100 consecutive patients with ACL tear treated with combined anterior cruciate-ligament reconstruction using semitendinosus tendon and iliotibial tract. They evaluated these patients using subjective and objective criteria at three to seven and one-half years after surgery. The authors found that after combined anterior cruciate-ligament reconstruction using semitendinosus tendon and iliotibial tract isokinetic muscle performance and passive tibial rotation showed significant improvements in strength and normalization of tibial rotation. The average time between injury and treatment in this study was found to be 3 years 2 months. In our study this time period was slightly less than other studies (1 year 10 months) [18].

In present series 46.47% of the injuries were due to road traffic accidents and 43.33% due to sports related trauma. Preponderance of injuries due to sports and road traffic accidents reflects the rising trend in competitive sports and increasing vehicular accidents. In our study ACL injuries due to road traffic accidents (46.66%) were more than that of

caused by sports activities (43.33%). This is in contrast with the studies conducted by western researchers. For example studies conducted by patond *et al* and Jones KG found sports activities to be the predominant cause of ACL injuries [19, 20].

Injuries to one or both menisci are frequently associated with grade III laxity of anterior cruciate ligament. The higher proportion of meniscal tears reflects the observation that in untreated anterior cruciate ligament deficient knees, the incidence of meniscal lesions increases with time. The co-existent meniscal injuries may be either the result of trauma which caused ACL tear or it may be secondary to faulty gear mechanism (due to ACL rupture) causing meniscal injury over a period of time. In our study 36.67% patients were found to have associated meniscal injuries. This incidence was slightly less than those reported by Zairns *et al*, Jones K.G and Finsterbush A [21]. The probable reason might be the fact the average time from injury to treatment was less in our study which might have been responsible for decrease incidence of secondary meniscal injuries.

The average hospital stay after surgery was 5-7 days after which patients were advised supervised physiotherapy. In our study, mean Tegner Lysholm score preoperatively was 60.5 ± 5.8, and mean Tegner Lysholm score 6 months after surgery was 91.2 ± 4.1. By using t-test, p value of <0.001 was obtained, which was highly significant statistically. Therefore, there was significant differences in pre-operative and knee score 6 months after surgery. Using Tegner Lysholm score our study found excellent results in 22 and good and fair results in 8 and 2 patients respectively. There was no patient with poor results at the time of 6 months follow up after surgery. Slightly different outcomes are reported from other studies conducted by Wilson *et al* (20% excellent, 73% good, 7% fair results) and Sharma *et al* (59% excellent, 19% good and 11% each for fair and poor results) [22, 23].

The analysis of complications in this study revealed that the complications were minor and seen only in a minority of the patients. The complication included wound infections (6.66%), wound edge necrosis (6.66%), foot drop due to tourniquet palsy (3.33%), chemical burns under tourniquet site (3.33%) and synovitis (3.33%). All these complication were managed conservatively and no residual complications were seen in any of the patients. Similar complication rates were seen in other studies by Shaerf DA *et al* and Andres – Cano *et al* [24, 25].

Conclusion

Management of anterior cruciate ligament still remains an enigma to the orthopedic surgeons. With increasing use of vehicles and rise in competitive sport activities injuries to ACL are on the rise. Conservative treatment of anterior cruciate ligament tears in the form of an extensive rehabilitation exercise program still remains an option in the management of anterior cruciate ligament tears. But if the patient has symptoms of instability, surgical intervention in the form of anterior cruciate ligament reconstruction remains the only option. Trying to treat these patients conservatively may result into secondary damage to menisci and resultant osteoarthritis may be difficult to manage. Our study found quadrupled semitendinosus autograft to be similar in strength and stiffness characteristics as that of normal anterior cruciate ligament and postoperatively patients had an excellent outcome. The complications associated with this surgical procedure were minor and could be managed conservatively.

Conflict Of interest: None

References

1. Kobayashi H, Kanamura T, Koshida S, *et al.* Mechanisms of the Anterior Cruciate Ligament Injury in Sports Activities: A Twenty-Year Clinical Research of 1,700 Athletes. *Journal of Sports Science & Medicine.* 2010; 9(4):669-675.
2. Petersen W, Tillmann B. [Anatomy and function of the anterior cruciate ligament]. *Orthopade.* 2002; 31(8):710-8.
3. Bonnet A. *Traité de thérapeutique des maladies articulaires.* J-B Baillière; New York, 1853.
4. Noyes FR, Butler DL, Grood ES, Zernicke RF, Hefzy MS Biomechanical analysis of human ligament grafts used in knee-ligament repairs and reconstructions *J Bone Joint Surg Am.* 1984; 66(3):344-52.
5. Friedman MJ. Arthroscopic semitendinosus (gracilis) reconstruction for anterior cruciate ligament deficiency. *Tech Orthop.* 1988; 2:74-80.
6. Streich NA, Reichenbacher S, Barié A, Buchner M, Schmitt H. Long-term outcome of anterior cruciate ligament reconstruction with an autologous four-strand semitendinosus tendon autograft. *International Orthopaedics.* 2013; 37(2):279-284.
7. Scott Trashman, Sebastian Kopf, Freddie Fu: The kinematics basis of anterior cruciate ligament reconstruction. *Oper Tech Sports Medicine.* 2008; 16(3):116-118
8. Colombet M, Allard V, Bousquet C, De Lavinge P, Flurin H. The history of anterior cruciate ligament surgery. Bourdeaux-Merignac Centre of Orthopaedic and Sports Surgery-9 rue Jean Moulin-F-33700 Merignac, France.
9. Komblatt I, Warren RF, Wickiewicz TL. Long term follow up of anterior cruciate ligament reconstruction using the quadriceps tendon substitution for chronic anterior cruciate insufficiency. *Am J Sports Med.* 1988; 16:444-448.
10. Sandberg R, Balkfors B, Reconstruction of the anterior cruciate ligament. A 5 year follow up of 89 patients. *Acta Orthop Scand.* 1988; 59:288-293.
11. Tegner Y, Lysholm J. Rating system in evaluation of knee ligament injury. *Clin Ortho Op,* 1985.
12. Kennedy JC. Application of prosthetic to anterior cruciate ligament reconstruction and repair. *Clin Orthop.* 1972, 125-128.
13. Leyshon RL, Channon GM, Jenkins DHR, Rallis ZA. Flexible carbon fibre in late ligamentous reconstruction for instability of the knee. *JBJS.* 1984; 66(2):196-200.
14. Weiss AB, Blazina MA, Goldstein AR, Alexander H. Ligament replacement with carbon fibre scaffold. Early clinical experience. *Clin. Orthop.* 1985; 196:77-82.
15. Shino K, Kimura T, Hirose H, Ono K. Reconstruction of the anterior cruciate ligament by cellogenic tendon graft. *JBJS.* 1986; 6B:739.
16. Bruchman WC, Bain JR, Bolton WC. Prosthetic replacement of the cruciate ligament with expanded polytetra fluoroethylene. In *cruciate ligament* Ed 7, Feagin F.A, New York. 1988,341-349.
17. Shafighian B, Strover AE, Mowbray M. Early clinical and arthroscopic results following reconstruction of anterior cruciate ligament with carbon fibre and polyester composite prosthesis. A personal communication, 1988.
18. Zairns B, Rawe CR. Combined anterior cruciate ligament reconstruction using semitendinosus tendon and iliotibial tract. *JBJS.* 1996; 68:161-176.
19. Jones KG. Reconstruction of the anterior cruciate ligament . A technique using the central third of the patellar ligament. *JBJS.* 1983; 45A:925-932.
20. Patond KR, Chauhan VD, Kumar N. Semitendinosus transfer for anterior cruciate ligament insufficiency. *Ind J of orthopaedics.* 1992; 26:1.
21. Finsterbush A, Frankl U, Matan Y, Mann G. Secondary damage to the knee after isolated injury of the anterior cruciate ligament. *Am J Sports Med.* 1990; 18(5):475-9.
22. Sharma UC. Intra-articular cruciate ligament reconstruction. *Indian journal of orthopaedics.* 1991; 2:106-109.
23. Wilson WJ, Fort Lewis, Scranton PE. Jr Combined reconstruction of anterior cruciate ligament in competitive athletes. *JBJS.* 90; 72A:742-748.
24. Shaerf DA, Pastides PS, Sarraf KM, Willis-Owen CA. Anterior cruciate ligament reconstruction best practice: A review of graft choice. *World Journal of Orthopedics.* 2014; 5(1):23-29.
25. Andrés-Cano P, Godino M, Vides M, Guerado E. Postoperative complications of anterior cruciate ligament reconstruction after ambulatory surgery. *Rev Esp Cir Ortop Traumatol.* 2015; 59(3):157-64.