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Is Aperture Fixation Superior to Cortical Fixation for Quadruple Hamstring Graft in Anterior Cruciate Ligament Reconstruction

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Abstract

Introduction: ACL is a commonly injured ligament of the knee. The incidence is rising due to increased motor vehicle accident. To regain full activity, its proper reconstruction is essential. Different technique developed over time to fix the graft to femur and tibia. Our study has compared the result of two fixation technique i.e. aperture fixation and cortical fixation.

Materials and Methods: In this prospective comparative study 60 patients were randomised into two groups. In group one(n=30) graft was fixe d using aperture fixation and in group 2 (n=30), using cortical fixation. All were followed at two, four, eight weeks and 6 months for evaluation by IKDC scoring, LYSHOLAM scoring, KT1000 arthrometer and measurement of tunnel widening.

Results: Both IKDC score and LYSHOLM score were better in aperture fixation group as compared to cortical fixation group at 6 month followup. The anterior translation of tibia was measured using KT 1000 arthrometer at 6 months. In our study, preoperatively we found significant difference between affected and unaffected knee at each force. Postoperatively we found there is no difference in KT-1000 reading between knees at each follow up. Aperture fixation group was also associated with less tunnel widening post operatively.

Conclusion: Aperture fixation method for ACL reconstruction provided a better LYSHOLAM, and IKDC score than cortical fixation. The tunnel widening at 6 months was less as compared to the cortical fixation group, as the anterior tibial translation. Thus, aperture fixation provides a strong and rigid fixation resulting in lesser chances of tunnel widening.

Keywords: ACL, LYSHOLAM, IKDC

Introduction

Anterior cruciate ligament (ACL) is one of the important intra-articular ligament of the knee joint. In today's world of motor vehicle accidents, sports injuries and other traumatic conditions causing twisting injuries to knee has led to an increase in the incidence of anterior cruciate ligament injury. Currently large numbers of ACL reconstructions are performed each year around the world. Therefore, the ACL has been one of the most frequently studied structures of the musculoskeletal system during the last decades. The prevalence of ACL injuries in the general population has estimated about one case in 3,500 people, resulting in 95,000 new ACL ruptures per year in United States.[1] The majority of these injuries are sustained during sport activities and is most common in the 2nd and 3rd decades.[2] The male: female ratio has been reported to be as high as 9:1.[3] Football, skiing, ice hockey and gymnastics are amongst the sports, while motorcycle or dashboard injuries forms the major percentage of vehicular accidents. According to Zarins and Victor,[4] the injury can either be in form of a contact injury, in which the

external force is directed across the knee or a non-contact in which an indirect force is applied to the knee. The most common contact injury is a clipping injury in which the athlete's leg is fixed to the ground in slight flexion and an opposing player hits him on the lateral or postero-lateral aspect of knee, causing a tear of the medial collateral ligament, medial capsule and ACL. A varus injury cause a tear of the lateral capsule and lateral collateral ligament. The most common non–contact injury is a combination of deceleration, valgus and external rotation of leg. This type of injury occurs in open field running, as the athlete plants his foot to decelerate suddenly or changes direction, which is known as pivoting or cutting.

Abott[5] and later Palmer[6] have described four mechanisms capable of producing disruption of knee ligaments. Abduction, flexion and internal rotation of the femur on tibia produce injury to the medial collateral ligament and anterior cruciate ligament. Adduction, flexion and external rotation of the femur on tibia produce injury to the lateral collateral ligament and anterior cruciate ligament. Anteroposterior displacement produces injury to both the anterior cruciate ligament and posterior cruciate ligament. Most of the time, lesions of the medial meniscus accompany that of the medial collateral ligament and anterior cruciate ligament and are termed as the, unhappy triad of O'Donoghue'.[7]

Diagnosis mainly rely on history, clinical examination (Lachman test, drawer test, and Pivot shift test), X Rays, MRI (accuracy 95% to 100%), and diagnostic arthroscopy. Lachman test is the most sensitive test (95% sensitivity) among the clinical tests.

Once the diagnosis is made, management can be divided into conservative and surgical. Correct choice of treatment depends on assessment of three patient factors: Age, Functional disability and Functional requirements. The management goal of the ACL injured patient is to prevent recurrent knee injury while allowing the patient to return to his or her previous activity. Injured ACL leading to instability of the joint makes patients more prone to developing arthritis and meniscal tear[8] which may take 12 to 15 years to develop.[9] After ACL tear there is alterations in function of knee which influences the articular cartilage mechanical environment, consequently altering the balance between synthesis and cleavage of cartilage and initiating onset of osteoarthritis.[10] ACL reconstruction results in normal anteroposterior laxity and lower the rate of post traumatic osteoarthritis progression.[11]The purpose of this study is to compare and evaluate the functional and radiological outcomes between aperture fixation and cortical fixation for ACL reconstruction using hamstring tendon graft.

Materials and Methods

In this prospective comparative study 60 patients of ACL tear were studied. Inclusion Criteria was patients in the age group of 20–50 years of age and of either sex, with unilateral ACL tear of more than two weeks, patients with evidence of ACL tear both clinical and radiologically. All patients were randomised into 2 groups. In group one (n=30) patients ACL repair was done using aperture fixation method, and in group 2 (n=30) it was repaired using cortical fixation.

The uninjured knee was examined first to establish the normal values for the Lachmann test, anterior drawer test & the Pivot shift test, after which the injured knee was examined. Injuries to other structures were ruled out by performing appropriate tests. The clinical examination included detailed history, noting the exact mechanism of injury, whenever possible, degree of instability and disability i.e. giving way, locking, inability to take part in active sports, recurrent swelling etc. Routine roentgenograms of both the knees were obtained in the standing position. A magnetic resonance imaging of the affected knee was performed in case of difficulty in clinical diagnosis of a symptomatic patient as and when required.

An informed written consent was taken and the patient information sheet was provided to the patient along with

detailed explanation of both the procedures. The patient medical history, demographics, vital signs, general physical examination, and the lab investigations were done. IKDC, LYSHOLAM scoring was done followed by KT1000 evaluation. Once the patient prepared, surgery was planned in both groups. After placing the patient in the supine position a thorough examination under anaesthesia is performed as per the clinical examination protocol. If the examination clearly demonstrates ACL tear, graft harvesting done.

Graft harvest: The sartorius aponeurosis is incised from its insertion to the tibia distal to underlying semitendinosus and gracilis tendon. Aponeurosis was everted, using digital palpation, the semitendinosus and gracilis tendons were isolated. Approximately 5-8 cm proximal to their tibial insertion, a no. 2 and no. 5 ethibond suture was used to tie distal end of tendons to control their free end. While traction is applied to the free end of tendon, the deep fascial bands to the gastrocnemius fascia can be identified and released. Premature transaction of semitendinosus tendon can occur without release of fascial attachments. With the knee flexed 30 -40 degrees, gentle traction is maintained on the distal end while closed tendon stripper is advanced proximally in line with the tendon.

Femoral tunnel preparation: Here we used transportal technique. The femoral guide with its offset of various number was inserted in knee joint through anteromedial port. Offset was put in such a position that its hook touches the posterior border of lateral femoral condyle. Then guide pin was inserted in max inferior position 2-3 mm forward keeping knee in 90º. After then hyperflex the knee and pass the guide pin through whole femoral condyle. We measured the length of femoral tunnel. Over this guide pin ream the tunnel with cannulated reamer a diameter equal to diameter of graft, upto desired length of graft, we want to put in femoral tunnel.

Tibial tunnel placement: Through the incision taken for graft harvest tibial tunnel is prepared. For the tibial tunnel, the ACL tibial drill guide is set at 55º and the tip of the drill guide is placed intraarticularly on the tibial footprint through anteromedial portal. On the tibial cortex, the tibial drill starts just anterior to the superficial medial collateral ligament fibres and it should come out just medial to anterior horn of lateral menisci. A tibial guide wire is passed in the stump of ACL foot print. After tibial guide wire was positioned in a satisfactory position, the tibial tunnel was established using a cannulated reamer corresponding to size of the graft.

Graft placement and fixation: Graft was passed through loop of endobutton for cortical fixation. In cortical fixation, the graft is passed through tibial tunnel and femoral tunnel with help of long suture. Passing suture and tensioning sutures comes out through lateral side of thigh, using passing suture (white in colour) we pulled the adjustable graft loop into the femoral tunnel until the mark on graft loop reaches the tunnel socket under direct arthroscopic visualization, indicating that button exited the femoral cortex proximally and ready to flip (green). Once the button flips, we pull hard on the graft to ensure solid femoral fixation. In the aperture fixation method the graft is pulled using the same two threads, but instead of flipping that is used in the endobutton, here it utilises polypropylene sheath (Fig. 1) which is placed as the graft is securely placed in the femoral tunnel in the marked position Then a guide wire is passes along the femoral tunnel and under vision of arthroscope the biointerference screw is tightened providing a stable fixation (Fig. 2).

Post operatively clinical assessment is done using IKDC SCORE, LYSHOLM SCORE and, KT1000 ARTHROMETER, and radiological assessment done using computed tomography for tunnel widening.

Statistical analysis was conducted with the statistical package for the social science system version SPSS 17.0. Continuous variables are presented as mean ± SD, and

categorical variables are presented as absolute numbers and percentage. The comparison of normally distributed continuous variables between the groups was performed using Student's t test. For comparison of variables pre-post intervention within the groups was performed using Paired t test.

Results

IKDC score evaluation

This is used for subjective knee evaluation. Table I shows IKDC score at different time period in both aperture fixation and cortical fixation group. There is significant increase in IKDC score in each follow up interval. As shown in Table II after 6 months of follow up in aperture fixation group we got excellent result in 66.66%, good result in 26.66%, fair result in 3.33% and poor result in 3.33%. As shown in Table III after 6 months of follow up in cortical fixation group we got excellent result in 50%, good result in 33.33%, fair result in 10% and poor result in6.66 %.

Lysholm and Gillquist score evaluation

This score is used to get objective functional outcome. Table IV shows Lysholm and Gillquist score at different time period in both aperture fixation and cortical fixation group. There is significant increase in Lysholm score in each follow up interval in both groups. As shown in Table V After 6 months of follow up we got excellent result in 73.33 %, good result in 16.66 %, fair result in 6.66 % and poor result in 3.33% for Aperture fixation. For same period of followup, we got excellent result in 60%, good in 30%, fair in 6.66% and poor in 3.33% for cortical fixation as shown in Table VI.

Tunnel diameter

Tunnel diameter is measured using CT SCAN at three different level for both femur and tibia. It is measured once postoperatively and another after six month. For femoral tunnel we found decrease in mean diameter at level L1 and L2 after 6 months of surgery (Table VII) and slight increase in diameter at level L3, which is insignificant. For tibial tunnel diameter there is slight increase in diameter at level L1 which is insignificant. There is decrease in mean tunnel diameter at Level L2 and L3 (Table VIII). On summarizing the femoral and tibial tunnel enlargements, the tunnel widening was found to be less in the aperture fixation group as compared to the cortical fixation group proving that aperture fixation is a much more stiff fixation as compared to the cortical fixation. Thus it provides less micromotion of graft within the tunnel resulting in lesser chances of tunnel widening.

KT-1000 arthrometer is used to evaluate anterior tibial translation preoperatively and postoperatively. In our study we measure this reading at different forces (5 lbs, 20 lbs, 30 lbs) of bilateral knee to compare affected knee from unaffected knee, at different interval of time during follow up (preoperative, 2 weeks, 8 weeks 3 months and 6 months). In our study, preoperatively we found significant difference between affected and unaffected knee at each force. Significance shown by p-value <.001, student's t- test was used. After surgery we found there is no difference in KT-1000 reading between knees at each follow up interval.

After 6 months of surgery, in the Aperture fixation group at 20 lbs we found 80% of patients have side to side difference less than 2 mm, 13.3% have this difference of 2-3 mm and 6.6% have >3 mm difference.

After 6 months of surgery, in the Cortical fixation group at 20 lbs we found 60% of patients have side to side difference less than 2 mm,33.3 % have this difference of 2-3 mm and 6.6 % have >3 mm difference.

Discussion

ACL is a vital ligament of the knee joint. It prevents anterior translation of tibia over femur. The cruciate ligaments perform function 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 abolishes the gear

mechanism which cannot be replaced satisfactorily by the peripheral ligaments and the joint capsule. Hence these secondary capsulo-ligamentous 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 ensues, leading ultimately to severe functional disability.

Kennedy et al[12] 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 Hamstring autograft is a popular procedure. The goal of treatment is to return the injured patient to the desired level of function.

In present study, selection of case 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 capsulo-ligamentous structures of the knee. Only those patients who had anterior laxity as tested by anterior drawer test and 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 60 cases treated over last two years. To date, no other study has been conducted concerning the ACL reconstruction technique using the graft attached to the femur with Aperture and Cortical fixation with a minimum follow-up of six months.

IKDC score was used for subjective evaluation. There is progressive increase in IKDC score at each follow up. After 6 months of follow up in aperture fixation group we got excellent result in 66.66 %, good result in 26.66%, fair result in 3.33% and poor result in 3.33%. After 6 months of follow up in cortical fixation group we got excellent result in 50%, good result in 33.33%, fair result in 10% and poor result in6.66%. Similar result found in a study by S. Plaweski in 2009, ACL was reconstructed using HT graft fixed with endobutton on femoral side, shows 60% excellent result, 35.3% have good result, 3.8% have fair result and 0.9% have poor result according to IKDC score.[13] In 2012 study by Keith W Lawhorn , comparing hamstring graft with allograft, in group of patients those treated with HT graft fixed with cross pin showed 85% have normal IKDC score, 7% have nearly normal score and 2% have severely abnormal score.[14]

Lysholm score was used for objective evaluation. There is progressive increase in Lysholm score at each follow up. After 6 months of follow up we got excellent result in 73.33 %, good in 16.66%, fair in 6.66% and poor in 3.33% for Aperture fixation and excellent result in 60%, good in 30%, fair in 6.66% and poor in 3.33% for cortical fixation. Thus there was a better overall score in aperture fixation.

Previously in a study by S. A. R. Ibrahim, in 2009 comparing ACL reconstruction between double and single bundle technique, in a group, those treated with single bundle technique in which graft fixed with endobutton on femoral side and bio screw on tibial side, according to Lysholm score 41% have excellent result, 44% have good, 14.6% have fair and none have poor result.[15] Ours and previous study shows almost similar results.

KT-1000 arthrometer measured tibial translation preoperatively and postoperatively at different forces (5 lbs, 20 lbs, 30 lbs) of bilateral knee to compare affected knee from unaffected knee, at different interval of time during follow up (preoperative, 2 weeks, 8 weeks, 3 months, and 6 months). Preoperative difference in anterior

translation was significant between affected and unaffected knee at each force. After surgery there is no difference in KT-1000 reading between knees at each follow up interval upto 6 month. After 6 months of surgery, in the Aperture fixation group at 20 lbs we found 80% of patients have side to side difference less than 2 mm, 13.3% have this difference of 2-3 mm and 6.6% have >3 mm difference. After 6 months of surgery, in the Cortical fixation group at 20 lbs we found 60% of patients have side to side difference less than 2 mm,33.3 % have this difference of 2-3 mm and 6.6 % have >3 mm difference.

Previously in a study by S. A. R. Ibrahim, in 2009 comparing ACL reconstruction between double and single bundle technique, in a group, those treated with single bundle technique in which HT graft fixed with endobutton on femoral side and bio screw on tibial side, found that difference of KT-1000 arthrometer reading between affected and normal knee, > 3mm at 20 lbs, in 33.33% of patient after 29 months of follow up. In another group in which graft was fixed with cross pin on femoral side and bio screw on tibial side has this difference in 27% of patient.[15]In a study by S. Plaweski in 2009, ACL was reconstructed using HT graft fixed with endobutton on femoral side, found that 54.3% of patients have differential laxity of 0-2 mm on KT-1000 arthrometer, 38.6% have laxity less than 5 mm and 7.6% have laxity between 5-10 mm.[13]In 2012 study by Keith W Lawhorn , comparing hamstring graft with allograft. Group of patient in which, hamstring graft is used and fixed with cross pin and bio screw found that after 2 yrs of follow up, 85% of patient have side to side differential laxity of 1-2 mm over KT-1000 arthrometer 13% have 3-5 mm laxity[14].CT scan is used to measure the tunnel diameter of femur and tibia. Both tunnels were measured at three different levels at two different interval, one post operatively and another after 6 months of surgery. For femoral tunnel we found decrease in mean diameter at level L1 and L2 after 6 months of surgery and slight increase in diameter at level L3, which is insignificant. For tibial tunnel there is slight increase in diameter at level L1 which is insignificant. There is decrease in mean tunnel diameter at Level L2 and L3.Tunnel widening was found to be less in the aperture fixation group as compared to the cortical fixation group proving that aperture fixation is a much more stiff fixation as compared to the cortical fixation. Thus it provides less micromotion of graft in the tunnel resulting in lesser chances of tunnel widening.Previously in 2009, study by S. Plaweski in which ACL was reconstructed using HT graft, fixed with endobutton there is constant tibial tunnel enlargement at 1 yr of follow up. Femoral tunnel enlargement >.5 mm was observed in all patients and 82% of patients have enlargement between 0.5-2 mm. At 4 yrs of follow up 27.6% of patients have femoral tunnel enlargement >2 mm. There was no modification in femoral tunnel diameter corresponding to endobutton loop. Expansion of the femoral tunnel was conical in shape in 60% and linear in 40% of cases.[13]

Conclusion

It's very crucial to make an accurate diagnosis of the ACL injury. This can be achieved most of the time by detailed history (including exact mechanism of injury), clinical examination including tests for rotatory instability and MRI.With use of arthroscopic assisted ACL reconstruction, the mean duration of hospital stay has been effectively decreased and incidence of infection can be kept low. Arthroscopic ACL reconstruction using semitendinosus and gracilis graft restored the stability of the knee with recovery in Lysholm and IKDC score and KT-1000 arthrometer reading equivalent to normal knee.

Based on the results aperture fixation in ACL reconstruction have an advantage of less enlargement of

tunnel diameter due to decreased micromotion of graft in tunnel as compared to cortical fixation. Aperture technique fill entire femoral socket with graft, hence ideal for short femoral socket. It is very tight construct hence it gives good result in form of IKDC and Lysholm score as compared to other mode of fixation. Aperture fixation utilises graft of variable length, thus reducing the complexity of surgery. There is no need to calculate size of implant which is required for other devices like endobutton.

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Tables

Table I: Showing mean IKDC score with standard deviation at different time during follow up

IKDC Scoring	Aperture Fix	Cortical Fix	P Value
	Mean ± SD	Mean ± SD	
Preoperative	49.60 ± 13.04	47.07 ± 9.62	0.395
2week	54.13 ± 6.01	54.21 ± 5.50	0.957
8week	60.85 ± 4.97	59.57 ± 5.64	0.355
3month	65.39 ± 5.42	65.01 ± 6.11	0.803
6month	70.77 ± 5.14	70.32 ± 6.87	0.773

Table II: Showing overall result of IKDC score for aperture fixation

Result of IKDC score			
	Score	No. of patient	Percentage
Excellent	>=71	20	66.66
Good	61-70	8	26.66
Fair	51-60	1	3.33
Poor	<=50	1	3.33
Total		30	100

Table III: Showing overall result of IKDC score for cortical fixation

Result of IKDC score			
	Score	No. of patient	Percentage
Excellent	>=71	15	50.00
Good	61-70	10	33.33
Fair	51-60	3	10.00
Poor	<=50	2	6.66
Total		89	100

Table IV: Showing mean Lysholm score with standard deviation at different time of follow up

Lysholm & Gillquist score	Aperture	Cortical	P Value
	Mean ± SD	Mean ± SD	
Preoperative	62.03 ± 6.20	58.83± 12.04	0.389
2week	67.67 ± 7.51	67.77 ± 6.88	0.957
8week	76.07 ± 6.21	74.47 ± 7.06	0.355
s3month	81.73 ± 6.77	81.27 ± 7.64	0.803
6month	88.47 ± 6.42	87.90 ± 8.58	0.773

Table V: Showing overall result of Lysholm Gillquist score for aperture fixation

Result of Lysholm Gillquist score			
	Score	No. of patient	Percentage
Excellent	>=93	22	73.33
Good	82-92	5	16.66
Fair	66-81	2	6.66
Poor	<=65	1	3.33
Total		30	100

Table VI: Showing overall result of Lysholm Gillquist score for cortical fixation

Result of Lysholm Gillquist score			
	Score	No. of patient	Percentage
Excellent	>=93	18	60.00
Good	82-92	9	30.00
Fair	66-81	2	6.66
Poor	<=65	1	3.33
Total		30	100

Table VII: Showing mean diameter of femoral tunnel at different levels with standard deviation comparing immediate postoperative and after 6 months of surgery .

Tunnel diameter (mm)		Aperture Fix	Cortical Fix
		Mean ± SD	Mean ± SD
Femoral L1	Immediate Post Operative	6.58 ± 1.17	6.92 ± 1.00
	Post 6 Months	6.84 ± 1.16	6.42 ± 1.38
Femoral L2	Immediate Post Operative	7.07 ± 1.43	7.26 ± 1.18
	Post 6 Months	7.34 ± 1.48	6.93 ± 1.17
Femoral L3	Immediate Post Operative	6.40 ± 1.44	6.59 ± 1.39
	Post 6 Months	6.67 ± 1.45	6.33 ± 1.14

Table VIII: Showing mean diameter of tibial tunnel at different levels with standard deviation comparing immediate postoperative and after 6 months of surgery

Tunnel diameter (mm)		Aperture Fix	Cortical Fix
		Mean ± SD	Mean ± SD
Tibial L1	Immediate Post Operative	7.45 ± 1.53	7.58 ± 1.57
	Post 6 Months	7.45 ± 1.16	7.91 ± 1.85
Tibial L2	Immediate Post Operative	8.67 ± 1.40	9.24 ± 1.79
	Post 6 Months	8.45 ± 1.48	8.88 ± 1.82
Tibial L3	Immediate Post Operative	8.60 ± 1.39	9.43 ± 1.90
	Post 6 Months	8.31 ± 1.71	8.91 ± 1.92

Figures

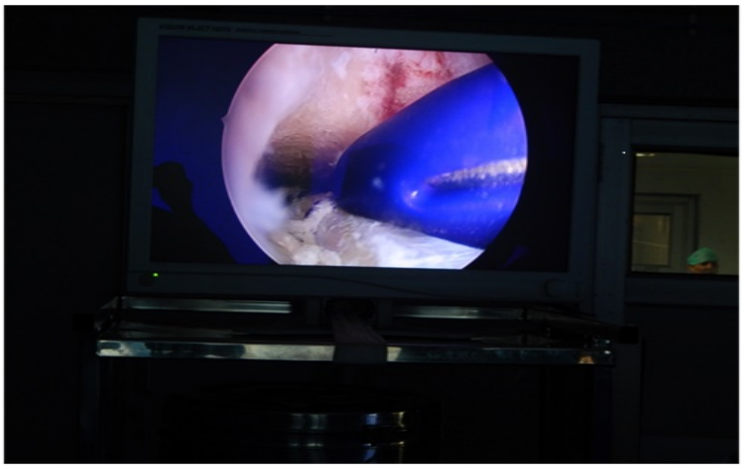

Figure 1:

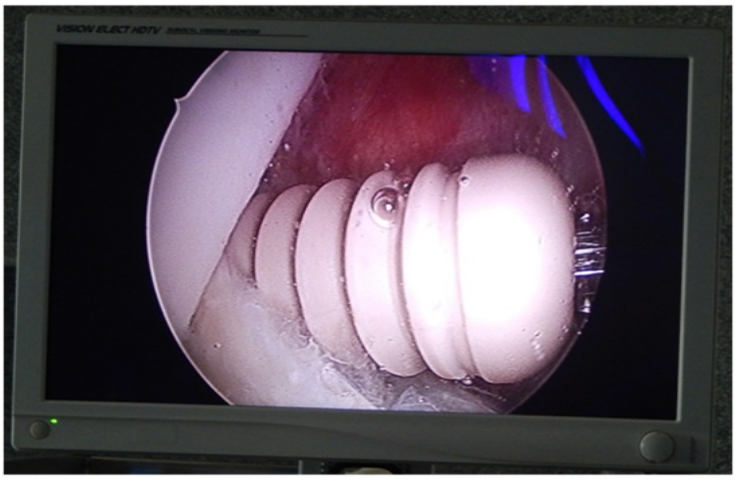

Figure 2: