

Cortical femoral suspensory fixation using screw post in anatomic single-bundle anterior cruciate ligament reconstruction: a prospective study and mid-term outcome results

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Abstract

Purpose Cortical femoral suspensory fixation using screw post in ACLR has the advantage of allowing complete filling of the femoral tunnel with graft tissue. In addition, the low cost of the implants is an advantage in countries where cost is an issue of concern. The purpose of the current study was to evaluate the clinical functional outcome results of cortical femoral suspensory fixation using screw post at mid-term follow-up.

Methods Single surgeon single centre prospective case series study. Sixty two patients having complete ACL tears were included in the current study. Average follow-up was 52.6 months (range 38–68). Objective and subjective IKDC scores, Lysholm knee score, SF-36 score, VAS for patients' satisfaction, VAS for pain and Kellgren & Lawrence (K/L) classification of osteoarthritis were used for follow-up evaluation.

Results Objective IKDC score revealed that 59 patients had grade "A" and 3 had grade "B", while no single patient had neither grade "C" nor "D". The average Lysholm score was 90.7, average subjective IKDC was 89.5. Average SF-36 score was 94.8. The average VAS for operation satisfaction was 9.4. Average VAS for pain was 0.2. Forty six patients were classified as normal K/L classification, nine were grade "1", seven were grade "2". Comparing pre-operative and follow-up objective IKDC, subjective IKDC, Lysholm, SF-36, and VAS

for pain scores revealed statistically significant differences (P -value <0.05).

Conclusion Femoral suspensory fixation using screw post in ACLR showed excellent functional outcome results at mid-term follow-up.

Keywords Anatomic anterior cruciate ligament reconstruction · Cortical suspensory fixation · Mid-term follow-up · Prospective study · Screw post

Introduction

The most commonly used anterior cruciate ligament (ACL) graft femoral fixation implants are interference screws, endobuttons, and cross pins. Studies have shown positive clinical outcomes for all three types of devices, and no definitive superiority has been shown for one method of fixation over another for either bone-tendon-bone (BTB) or soft tissue grafts [1–4].

However, biomechanical studies showed concerns that interference screws may allow for some graft slippage and failure at lower ultimate tension loads when used for fixation of hamstring tendon grafts [5, 6]. Cross-pins, in contrast, have shown to provide stronger fixation and high failure loads but were associated with several intra-operative and post-operative complications [7].

Biomechanical studies showed that fixed-length cortical suspensory graft fixation devices such as endobuttons are a good option for soft tissue graft fixation in terms of limiting graft slippage and providing sufficient fixation strength. However, there are technical challenges regarding its insertion [8]. Because the loop length is predetermined, surgeon has to drill the femoral tunnel to a specific depth while selecting a corresponding endobutton of appropriate length. Any error in

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measurement can lead to difficulty in passing the endobutton via the lateral femoral cortex or can result in insufficient graft length available in the femoral tunnel for graft incorporation. Furthermore, recent studies showed that anatomic femoral tunnel placement results in shorter tunnel length and further concern for sufficient graft length available in the femoral tunnel [9].

Cortical femoral suspensory fixation using screw post has the advantage of allowing complete filling of the femoral tunnel with graft tissue. In addition, the low cost of the implants is an advantage in countries where cost is an issue of concern.

The purpose of the current was to evaluate the functional outcome results of cortical femoral suspensory fixation using screw post at mid-term follow-up.

Hypothesis was that cortical femoral suspensory fixation using screw post in anterior cruciate ligament reconstruction (ACLR) will show excellent functional outcome results at mid-term follow-up.

Methods

The current study was conducted as a single surgeon, single centre prospective case series study. Between July 2009 and January 2012, 87 patients having complete ACL ruptures underwent arthroscopic assisted anatomic ACLR using trans-portal femoral tunnel drilling technique and cortical femoral suspensory fixation on screw post. Hamstrings (Gracillis and Semitendinosus) quadrupled autografts were used for ACLR in all patients. All reconstructions were performed by the first senior author.

Inclusion criteria were: 1) skeletally mature patients; 2) complete ACL tears; 3) healthy contralateral knee. Exclusion criteria were: 1) skeletally immature patients; 2) partial ACL tears; 3) multiligamentous injuries; 4) prior intra- or extra-articular ligament reconstruction; 5) moderate or severe osteoarthritic changes; grade 3 or 4 Kellgren and Lawrence (K/L) classification [10].

An informed consent of agreement to participate in the current study was signed by all patients. All participants were encouraged to remain in the study after surgery; however, participants were given the right to withdraw from the study at any time for any reason.

Only 62 patients were available for the follow-up evaluation which was conducted in March 2015.

Fifty four patients were males, while eight were females. Forty three were right knees and 19 left. The average age of patients at the time of surgery was 30.5 years [standard deviation (SD) 2.9 years] (range 20–38). The average age of patients at the time of the follow-up evaluation was 35.8 years (SD 2.6 years) (range 23–44). The average time between injury and surgery was 6.8 weeks (SD 1.4) (range 4–10). The

average follow-up was 52.6 months (SD 3.7 months) (range 38–68).

Forty one patients had the injury during recreational sports, while 21 had the injury during activities of daily living (ADL).

Twenty three patients had associated medial and/or lateral meniscal tears. All 23 tears were treated at the time of ACLR by partial meniscectomy.

Primary outcome measures included; three knee scoring systems; the Objective International Knee Documentation Committee score (IKDC) [11] which depends mainly on findings from clinical examination of the knee, Subjective IKDC score [11] which depends on symptoms, sports activities and function and the Lysholm knee score [12]; which depend on subjective knee symptoms as pain, swelling, instability, etc.

Secondary outcome measures included; the short form 36 (SF-36) health survey score [13], which depends on subjective evaluation of the patient's quality of life. Two visual analogue scales (VAS) for pain and patient satisfaction. The 1st VAS was for assessment of patients' satisfaction ranging from -10 to +10 and another VAS for assessment of patients' pain ranging from 0 to 10. A question was asked to all patients and their parents whether they would agree to undergo the same procedure if they experience another torn ACL in the future. The K/L classification of osteoarthritis was used for all patients, which consists of four grades; grade 1 "doubtful": minimal osteophyte, doubtful significance; grade 2 "minimal": definite osteophyte, unimpaired joint space; grade 3 "moderate": moderate diminution of joint space; grade 4 "severe": joint space greatly impaired with sclerosis of subchondral bone [10].

All the above mentioned scores were completed and recorded pre-operatively as well as at the time of the follow-up evaluation. All patients had supervised assistance to correctly and completely fill in the different scoring forms.

Plain erect antero-posterior and lateral x-rays and magnetic resonance imaging (MRI) were done to all patients pre-operatively. Post-operatively, only x-rays were done.

Surgical technique

Standard arthroscopic equipment was used; 4 mm, 30° arthroscope, basic ACL reconstruction set, pump set at 35 mmHg pressure, motorized shaver and high pullout strength size 2 suture material [FiberWire® (Arthrex Inc., Naples, Florida USA) or Orthocord® (DePuy Mitek Inc., Raynham, MA USA)].

The three-portal approach to the knee is used, comprising the standard anterolateral portal, central medial portal and the accessory medial portal (AMP) [14, 15].

Diagnostic arthroscopy is first performed to confirm the diagnosis of complete ACL tear. Harvesting of the Semitendinosus and Gracilis tendons is performed and a quadrupled graft is prepared.

Drilling the femoral tunnel

With the knee flexed 110°, the guide pin is inserted via the AMP [16, 17] and drilled through the center of foot print. To avoid injury to the medial femoral condyle articular cartilage, a bio-interference screw sheath (Arthrex Inc., Naples, Florida USA) [15] is inserted through the AMP over the guide pin and the drill bit is inserted through the bio-interference screw sheath to drill the femoral tunnel.

Drilling the tibial tunnel

Drilling the tibial tunnel is done the regular way.

Passing the graft

The guide pin containing a suture loop in its slotted end is inserted through the AMP into the femoral tunnel. Using a probe inserted via the tibial tunnel, the loop is grasped and passed out of the joint via the tibial tunnel. The two high pullout strength graft sutures are passed via the loop and the guide pin is pulled back from the femoral tunnel, driving the graft sutures outside the joint. The graft sutures are pulled driving the graft through the tibial and the femoral tunnels (Fig. 1).

Graft fixation

A 3 cm skin incision is performed proximal to the point where the graft sutures exit the femoral lateral cortex. Iliotibial band is incised in line of the skin incision. Blunt dissection (muscle splitting) is performed down to bone. The graft sutures are retrieved from the incision. A 20–30 mm 6.5 titanium screw with washer is fixed to the lateral femoral cortex and the graft

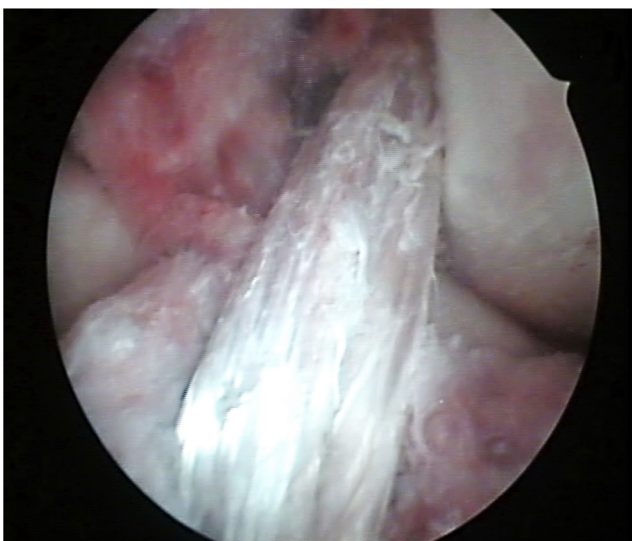


Fig. 1 The final graft position is checked via the AMP portal where it has to show a horizontal lie in order to provide rotational stability

sutures are tied securely over the head and washer of the screw. Measures to secure the knots are taken as; several half hitches, past pointing (using a knot pusher) and interchanging the post and loop. The graft is cycled and a biodegradable interference screw is inserted into the tibial tunnel.

Closure

Excision of excess graft length at the tibia is performed, and a suction drain is inserted intra-articular (for 24–48 h). Closure of iliotibial band, subcutaneous tissue, skin incisions and portals is performed.

After treatment

Patients are placed in a hinged-knee brace locked in extension. Range of motion exercises are encouraged immediately post-operative. Weight bearing with the brace locked in extension until one month, then with unlocked hinged brace until three months. Running in a straight line and muscle strengthening exercises starts after three months [18]. Pivoting and return to full sports are not allowed before six months.

At the time of follow-up evaluation, only plain erect antero-posterior and lateral x-rays were done to all patients (Fig. 2).

Statistical analysis

Acquired data was analyzed with SPSS version 17 software program for windows. The average (mean), standard deviation, mode, median, and range were calculated for the results of the used clinical scores. When comparing pre-operative and post-operative scores, significance level was set at $P < 0.05$.

Results

Primary outcome measures

At the time of the follow-up evaluation (average follow-up was 52.6 months, SD 3.7 months, range 38–68), 59 patients had grade “A” (the highest grade) according to the objective IKDC score, three patients had grade “B”, while no single patient had neither grade “C” nor “D” (the lowest grade) (Table 1). Average subjective IKDC score was 89.5 (SD 7.3) (range 70.1–100). The average Lysholm score was 90.7 (SD 9.2) (range 87–100) (Table 2). Pre-operatively, 34 patients had grade “B” according to the objective IKDC score, 27 patients had grade “C”, five patients had grade “D” and no single patient had grade “A”. Average subjective IKDC score was 38.4 (SD 14.5) (range 33.3–44.8). Average Lysholm score was 28.7 (SD 11.2) (range 18–40).

Fig. 2 *a, b*: anteroposterior and lateral x-ray views done at the follow-up evaluation



Secondary outcome measures

At the time of the follow-up evaluation average, average SF-36 score was 94.8 (SD 11.4) (range 84.9–100), VAS for operation satisfaction was 9.4 (SD 0.4) (range 9–10), and average VAS for pain at the time of the follow-up evaluation was 0.2 (SD 0.3) (range 0–1) (Table 2). Asking the patients whether they would undergo the same procedure if they experience another complete ACL tear in the future, all 64 replied “Yes”.

Pre-operatively, average SF-36 score was 26.4 (SD 9.8) (range 16.8–40.3), VAS for pain was 8.2 (SD 1.2) (range 8–10).

Comparing pre-operative and follow-up objective IKDC, subjective IKDC, Lysholm, SF-36, and VAS for pain scores revealed statistically significant differences (P -value <0.05) (Table 3).

Pre-operatively, 50 patients were classified as normal according to K/L classification, while 12 patients were K/L classification grade “1”. At the time of the follow-up evaluation, 46 patients were classified as normal according to K/L

classification, nine were grade “1” (doubtful), seven were grade “2” (minimal). Analysis of those who had osteoarthritis progression (seven patients) at the time of follow-up evaluation, revealed that all seven had concomitant medial and lateral meniscal tears and underwent arthroscopic partial meniscectomy. In addition, all seven patients had body mass index 25–30.

At the time of the follow-up evaluation, all 62 patients showed complete ROM (extension and flexion) [19], 48 patients had negative Lachman test, negative anterior drawer test, and negative pivot shift test, while 14 patients had grade 1 positive Lachman test, negative anterior drawer test and negative pivot shift test. No single patient had an instability complaint either during ADL or recreational sports.

At the time of the follow-up evaluation, all patients were able to return to their pre-injury level of activity and to participate in recreational sports.

Discussion

The most noteworthy finding in the current study is that mid-term follow-up evaluation of patients who underwent cortical femoral suspensory fixation using screw post in ACLR showed excellent clinical outcome results as 59 patients had grade “A” (the highest grade) according to the objective IKDC score, average subjective IKDC score was 89.5, average Lysholm score was 90.7, average SF-36 score was 94.8, average VAS for pain was 0.2, and all 62 patients replied “Yes” when asked whether they would undergo the same procedure if they experience another complete ACL tear in the future.

For graft incorporation to take place, it needs at least six to 12 weeks [20]. Before this time, the graft experience loads of

Table 1 Frequency of the different grades of the objective IKDC score among patients pre-operatively and at the time of follow-up

OIKDC grade	Pre-operative	Follow-up
OIKDC “A”	0	59
OIKDC “B”	34	3
OIKDC “C”	27	0
OIKDC “D”	5	0
Total	62	62

OIKDC objective international knee documentation committee score, grade A normal, grade B nearly normal, grade C abnormal, grade D severely abnormal

Table 2 Average, median, mode, standard deviation, variance, range, minimum, and maximum of modified Lysholm score, subjective IKDC, SF-36, VAS for patient satisfaction and VAS for pain among patients at the time of the follow-up evaluation

	Average	SD	Median	Mode	Range	Minimum	Maximum
Lysholm score	90.7	7.2	91, 100	100	9	87	100
Subjective IKDC	89.5	7.3	90.8, 91.9	91.9	29.9	70.1	100
SF-36 score	94.8	11.4	84.9, 100	100	15.1	84.9	100
VAS for satisfaction	9.4	0.4	10, 9	9	2	9	10
VAS for pain	0.2	0.3	1, 0	0	1	0	1

IKDC International Knee Documentation Committee score, *SF-36* short form 36, *VAS* visual analogue scale, *SD* standard deviation

at least 450–500 N during early rehabilitation [21] and depends mainly on the fixation method to maintain tension. Insufficient graft length available in the femoral tunnel [22] is a concern when using fixed-length cortical suspensory graft fixation devices such as endobuttons (commonly used worldwide). Cortical femoral suspensory fixation using screw post lacks the previous disadvantage because the graft completely fills the femoral tunnel which allows more graft tissue volume to be incorporated in the tunnel bone.

Fixation of hamstring grafts with sutures over buttons, sutures over posts have been previously described [6]. To our knowledge, this is the first report on the clinical outcome results of femoral suspensory fixation using screw post in anatomic anterior cruciate ligament reconstruction.

Miata et al. [23] reported good biomechanical properties of femoral suspensory fixation using screw post. However, disadvantages included low stiffness of the graft complex and rapid relaxation of the graft tension.

Recently, Barrow et al. [24] compared the biomechanical properties of cortical suspension adjustable-length fixation devices versus fixed-length fixation devices and found that the ultimate tension load of both graft-fixation devices exceeded the forces experienced in a patient's knee during early postoperative rehabilitation period. However, the adjustable-length fixation devices experienced a clinically significant increase in loop lengthening during cyclic testing. This lengthening is partially caused by suture slippage into the adjustable-length loop. Slippage negatively affects both postoperative healing and clinical outcomes because of increased graft laxity. Other studies have shown similar results [8].

Table 3 Comparison between pre-operative and follow-up subjective IKDC, modified Lysholm, SF-36, and VAS for pain scores

	Pre-operative	Follow-up	P-value
Lysholm score (average)	28.7	90.7	<0.05
Subjective IKDC (average)	38.4	89.5	<0.05
SF-36 (average)	26.4	94.8	<0.05
VAS for pain (average)	8.2	0.2	<0.05

IKDC International Knee Documentation Committee score, *SF-36* short form 36, *VAS* visual analogue scale

Brucker et al. [25] reported on the disadvantages of aperture and suspensory fixation and found that disadvantages of suspensory fixation include; graft tunnel motion, windshield wiper action, suture stretch-out, tunnel enlargement, delayed graft incorporation and secondary rotational and anterior instability.

Cortical femoral suspensory fixation using screw post has the advantage of allowing complete filling of the femoral tunnel with graft tissue. In addition, the low cost of the implants is an advantage in countries where cost is an issue of concern.

Limitations of the current study are: 1) no long-term follow-up; 2) no MRI imaging studies were done in the follow-up, but this would have added a huge extra cost to the study; 3) small number of patients (less than 100); 4) not all patients were available for the follow-up evaluation (62 out of 87).

Conclusion

Femoral suspensory fixation using screw post in ACLR showed excellent functional outcome results at mid-term follow-up.

Compliance with ethical standards Authors certify that all procedures performed in the current study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest None.

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