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Original Article

Outcome of posterior wall blowout in anterior cruciate ligament (ACL) reconstruction via anteromedial portal approach: A retrospective research in 20 patients with 6 years follow-up

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ABSTRACT

Purpose: To evaluate the clinical outcome in patients who received anterior cruciate ligament (ACL) reconstruction via anteromedial portal with or without posterior wall blowout.
Methods: Twenty patients with ruptured ACL, who have received ACL reconstruction via anteromedial portal between Apr 2012 and Oct 2013 were enrolled. According to the conditions of posterior wall, the patients were divided into 2 groups: posterior wall blowout group (10 patients) and posterior wall intact group (10 patients). The median follow up time were 63 (range 19–75) months and 60.5 (range 25–64) months in the 2 groups respectively. The clinical outcome was evaluated by knee joint physical examination, magnetic resonance imaging (MRI), the International Knee Documentation Committee (IKDC) 2000 subjective score, Lysholm score, Tenger score, difference of thigh circumference, KT-2000 and Biodex isokinetic dynamometer system.
Results: No significant differences were found in terms of the IKDC score, Lysholm score, Tegner score, Lachman test positive rate or Pivot Shift test positive rate between the two groups. In KT-2000 and Biodex isokinetic dynamometer tests, the difference of muscle strength between affected knees and unaffected knees in posterior wall blowout group was not significant less than that of posterior wall intact group ($p > 0.05$). In addition, there is no statistical difference between the two groups in signal/noise quotient (SNQ) of the graft ($p > 0.05$) in post operative MRI.
Conclusion: Blowout of posterior wall in ACL reconstruction via anteromedial portal does not affect the clinical outcome as long as reliable fixation has been taken intraoperatively.

Introduction

Anterior cruciate ligament (ACL) injury is the most common ligament injury in knee joint. The gold standard of treatment is the reconstruction of the ligament with arthroscopy using allografts or autografts. The traditional operation method is to build a femoral tunnel with transtibial technique and fix the graft to femur and tibia. In recent years, some researchers suggest that the reconstruction of the femoral tunnel via anteromedial portal of the knee joint may achieve better stability.[1–4] However, this surgical technique is slightly more complicated than traditional method, and on account of the drilling angle to the bone as well as the shape of the femur, the posterior wall of the femur may easily get blown out,[5] especially in surgeons who lacks experience. The posterior wall blowout may fail the fixation of the graft, or affect the healing of tendon to the bone, and finally cause loosening of the graft. In dealing with such situation, one solution is to do an additional incision on the femoral side to fixate the graft with some other devices,[6,7] another approach is to allow natural healing without any additional measures if the tendon fixation is still valid. According to our clinical observation, it is not necessary to do the extra incision on the femoral side as long as fixation is confirmed effective, and there is no significant difference on the outcome. This study is designed to assess the prognosis of patients with posterior wall blowout in the femoral bone tunnel who have undergone reliable

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fixation, by comparison with patients in the same period who have had intact posterior wall of the femoral tunnel after ACL reconstruction. We assume that the partial blowout of the posterior wall will not affect the healing of tendon, or may even have a better result in the healing and reconstruction of blood supply to the autograft because of the direct contact between the interface of the graft and periosteum.[8] This may provide more accurate direction for future clinical work.

Methods

Clinical materials

Of all the patients who received ACL reconstruction performed by the corresponding author in our institute between April 2012 and November 2013, thirteen patients sustained posterior wall blewout incidentally during operation. Three of these patients lost follow-up and finally 10 met with the inclusion criteria. The criteria are as follows. (1) Using anteromedial portal approach for operation and having been diagnosed posterior wall blowout of the femoral tunnel in both intraoperative arthroscopy and postoperative imaging. (2) The fixation of autograft was confirmed valid in operation. For control group, we randomly selected 10 patients who received ACL reconstruction in the same period by the same surgeon but had normal femoral tunnels in postoperative computed tomography (CT) imaging (Figs. 1 and 2). There is no significant difference between the two groups in gender, age, follow-up time, preoperative subjective score, KT-2000 test and Biodex isokinetic test (Tables 1 and 2). All of the posterior blowouts of the femoral tunnel were accidental. Informed consents were obtained prior to surgery.

All patients' data were recalled from the patients' files. Informed consent exempted for retrospective research and without privacy disclosure. This study was approved by the Ethics Committee of Peking University Third Hospital.

Surgical technique

All the ACL reconstructions for patients enrolled to the study were performed via anteromedial portal with autogenously hamstring single-bundle reconstruction. The femoral side of the autograft was fixated with Endobutton (Smith & Nephew, USA) and the tibial side was fixated to the tibial tunnel with Intrafix (Smith & Nephew, USA). In patients with posterior wall blowout of femoral tunnel, there were no additional methods to fixate the graft after we confirmed that the fixations by Endobutton were not loose during the operations.

Rehabilitation

For postoperative rehabilitation, all participants in the study adapted the same plan. All patients started taking leg lift exercises and walking with partial weight bearing immediately after surgery and started to flex the knee joint to 90° 4–7 days after the surgery. Active flexion of the knee to 110° was introduced 4 weeks after surgery and 120° at 6 weeks. Partial weight bearing in first 3 weeks and the knee braces could be removed 3 months after the surgery when the active range of motion was almost the same as the unaffected side. Patients could resume daily activities including jogging, rope skipping, and swimming 4–6 months after surgery.

Follow-up

All patients were re-examed in outpatient setting 6 months post surgery. CT scan was used to evaluate the posterior wall of femoral tunnel and MRI to assess the tendon's growth and tendon-bone healing. We obtained the subjective evaluation scores, qualitative and quantitative data 1–2 years after surgery.

The subjective scoring system included the International Knee Documentation Committee (IKDC) subjective knee score,[9] Lysholm score[10] and Tegner score.[11]

Qualitative assessing methods included physical examinations such as Pivot-Shift test, Lachman test and the anterior drawer test (ADT). Anterior Drawer test[12] is the most commonly used physical examination for displacement of the knee. It is usually carried out then the knee flexed at 90°, neutral position, 30 degrees of external rotation and 15 degrees of internal rotation. Lachman test,[13] a variant of the ADT, performed with knee 15° flexion and external rotation to quantify displacement. It has been proved to be more reliable than ADT. For both ADT and Lachman test, laxity of 0–5 mm

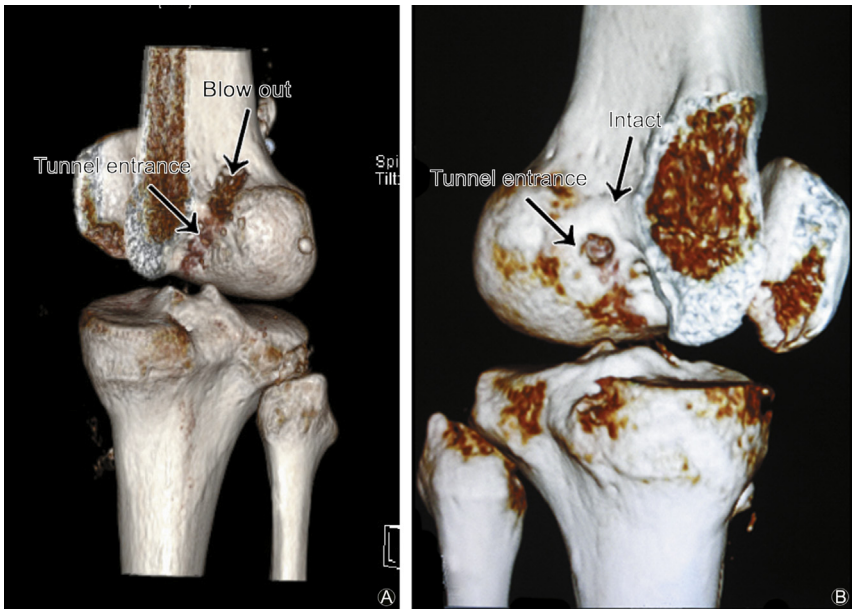

Fig. 1. Three-dimensional reconstructions of CT scan. (A) Partial blowout in posterior wall in the femoral tunnel. (B) Intact posterior wall of the femoral tunnel.

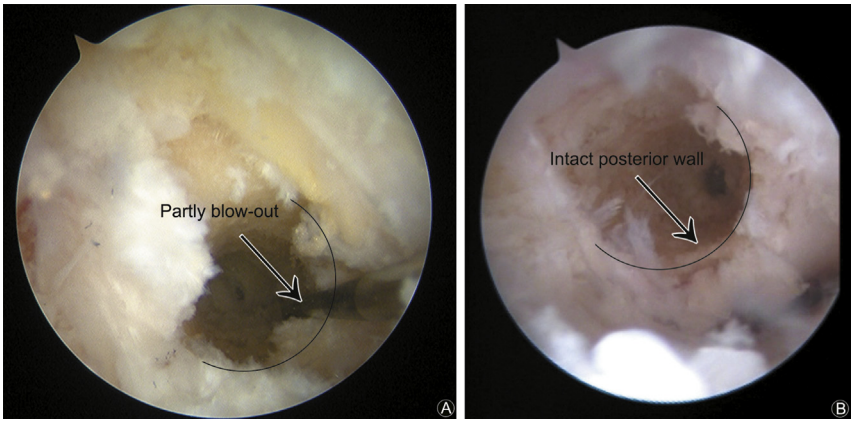

Fig. 2. Arthroscopic views. The circular outline indicates the posterior bony wall of the femoral tunnel. (A) The arrow shows the blowout of posterior wall. Due to the inconstancy of the posterior wall, some of the soft tissues went into the tunnel with liquid flow. (B) The arrow shows an intact femoral tunnel.

Table 1
Demographics, subjective scores and physical examinations ($n = 10$ for each group).

Variables	Blowout group	Control group	*p* value
Age (year)[a]	25 (21, 33) (16–59)	24 (21, 40) (15–42)	0.831
Gender (M/F)	8/2	8/2	1
Follow up (month)[a]	63 (56, 71) (19–75)	60.5 (56, 63) (25–64)	0.393
BMI[a]	23.6 (22.9, 25.1) (16.8–26.6)	25.15 (23.7, 27) (19.5, 29.1)	0.190
Preoperative			
IKDC score[a]	60.35 (55.17, 66.7) (42.52–80.4)	62.07 (58.62, 65.51) (49.43–87.36)	0.631
Lysholm score[a]	68 (59, 75) (43–96)	65 (52, 70) (46–88)	0.529
Tegner score[a]	3 (2, 4) (2–5)	3 (3,4) (2–6)	0.393
Positive Lachman Test	9	10	1
Positive Pivot Shift Test	7	5	0.650
Positive ADT	10	8	0.474
Postoperative			
IKDC Score[a]	86.23 (80.46, 96.55) (79.31–100)	81.61 (78.16,89.66) (79.31–100)	0.165
Lysholm Score[a]	90 (80,100) (80–100)	87.5 (77,96) (68–100)	0.315
Tegner Score[a]	6 (5,6) (3–9)	4.5 (3,6) (3–7)	0.143
Positive Lachman Test	0	0	N/A
Positive Pivot Shift Test	0	0	N/A
positive ADT	0	0	N/A

Abbreviations: BMI: body mass index; M: male; F: female; ADT: anterior drawer test.
[a] Data were expressed as median (25th percentile, 75th percentile) (minimum-maximum).

Table 2
Comparison of KT-2000 and Biodex isokinetic test.

Items	Blowout group[a]	Control group	*p* value
Preoperative $n = 9$:10 (Blowout group: Control group)			
KT-2000	5 (4.4, 5) (3.8–10)	4 (4,6) (3.00–6)	0.243
120° extension %[a]	28.91 (23.82, 45.07) (16.74–68.52)	26.79 (1.13, 45.28) (−43.10–69.47)	0.604
120° flexion %[b]	54.93 (27.61, 57.34) (−12.16–79.46)	27.89 (−0.88,59.32) (−27.55–68.32)	0.604
60° extension %[c]	33.76 (8.10,46.85) (−4.92–64.24)	30.33 (0, 37.34) (−12.74–69.96)	0.447
60° flexion %[d]	31.43 (10.79,51.88) (−8.13–61.31)	21.54 (12.96,29.70) (−6.59–75.05)	0.720
Postoperative $n = 10$:10 (Blowout group: Control group)			
KT-2000	1.16 (0.78, 2.49) (−0.83–2.9)	1.89 (1.62, 2.13) (−1.53–4.01)	0.315
120° extension %	5.71 (−3.82, 18.49) (−29.72–34.05)	18.23 (9.21, 27.95) (−22.56–42.65)	0.143
120° flexion %	0.98 (−6.87, 18.43) (−45.05–52.88)	21.92 (4.82, 28.99) (−2.72–41.71)	0.063
60° extension %	3.43 (−3.55, 19.64) (−28.46–40.12)	9.55 (−1.70, 34.11) (−5.71–57.01)	0.481
60° flexion %	15.44 (−19.20, 24.57) (−33.72–29.04)	18.72 (12.64, 29.41) (2.61–33.13)	0.247

The deficit percentage of peak torque between involved side and uninvolved side under the speed of [a]120 deg/sec, extension; [b]120 deg/sec, flexion; [c]60 deg/sec, extension; [d]60 deg/sec, flexion.
Data were expressed as median (25th percentile, 75th percentile) (minimum-maximum).
Deficit percentage = (Peak torque of uninvolved side − Peak torque of involved side)/Peak torque of uninvolved sided.
[a] $n = 9$ for 1 case without preoperative KT-2000 and Biodex test.

greater than the uninvolved side is defined as mild grade, while 6–10 mm moderate, 11–15 mm severe. Pivot Shift Test,[14] a common tool to evaluate instability of the knee, is performed with patients lying in supine position, with hip in 30° flexion. The physician stands lateral on the patient on the side of examed knee. With the leg and ankle grasped maintaining 20 degrees of internal rotation, the examiner's hand increase the force of internal rotation and valgus force, the knee is slowly flexed to test instability.

KT-2000 system is to measure the deficit (mm) of the affected to non-affected knee. The shift was recorded automatically when the

force reached 44N, 66N, 88N and 132N. We used the difference of the shifts in 132N between affected and unaffected knee as a statistic to assess the effectiveness of the surgery. Every patient was in a supine position with knee flexed to 30°. The neutron position of the knee was defined as the rest position.

Biodex isokinetic dynamometer system is a test to evaluate the recovery of muscle strength after surgery. We obtained the peak torque (N·m) when patients were extending and flexing the knee joint in the speed 60 deg/sec and 120 deg/sec and then calculated the deficit percentage between the affected and unaffected knee. The deficit percentage = 1- (Peak torque in the affected side)/(Peak torque in the unaffected side).

Six months postoperatively, each patient had magnetic resonance imaging (MRI) with 1.5-tesla open-bore magnet (GE Signa, GE Healthcare, USA). Standard oblique coronal proton density-weighted images (PDWI) with 3 mm slice thickness were adopted for analysis of graft maturity. The repetition time (TR) was 2000–3000 ms and echo time (TE) was 10–40 ms for PDWI. We selected 3 interest regions of the graft (upper, middle and lower) and 1 interest region of posterior cruciate ligament (PCL).[15,16] The signal intensity was measured to calculate the signal/noise quotient (SNQ). SNQ = [signal (specific site of the graft) -signal (PCL)]/signal (background).

Statistical methods

Statistical analysis was performed with SPSS 21.0 software and PASS 14.0. The measurement data were expressed as Median (Percentile 25, Percentile 75) (Minimum-Maximum) and were compared by using Nonparametric test (Mann-Whitney *U* test), including all the subjective scores as age, follow-up time, Biodex isokinetic test and KT-2000 test. Enumeration data were compared with Fisher Exact test including Sex, Lachman test, Pivot shift test and anterior drawer test. We calculated the Power Value for the SNQ comparison with PASS 13.0 software.

Results

Of the 125 patients underwent ACL reconstruction by the corresponding author of the investigation from 2013 to 2014, 10 presented with posterior wall blowout. In total, twenty patients were enrolled to the study. No patient complained of obvious swelling, pain, unstable or stiffness of the knee. All patients had negative results for postoperative physical examination, including Lachman test, ADT and Pivot shift test. The median followed-up time was 61.5 months (range 19–75 months).

The subjective scores and physical examination data are shown in Table 1. The IKDC score, Lysholm score and Tegner score in the blowout group are better than those control group without significant difference ($p > 0.05$).

KT-2000 Test data in 132N's force, Biodex isokinetic data and postoperative SNQ of the graft are listed in Tables 2 and 3. As is shown, KT-2000 test in the blowout group is better than that in the control group, but not significant ($p > 0.05$). There is no statistical difference between the two groups in postoperative SNQ of the graft ($p > 0.05$). The Power of the SNQ negative result is 0.141.

Table 3
Comparison of postoperative signal/noise quotient of the graft ($n = 9$ for each group).

Group	Median and quartile	Mean	Standard deviation
Blowout	4.92 (2.98, 6.19)	4.88	4.75
Control	5.40 (2.94, 7.91)	7.53	6.38
p value	0.666		

Power = 0.141.

Discussion

As previously discussed, transtibial approach and anteromedial portal approach are the most commonly used approaches to build femoral tunnel in ACL reconstruction. Many researchers have reported the advantage of anteromedial portal approach for more approximate to the anatomic position as well as gaining more stability of knee joint including rotational and anterior-posterior plane,[1–3,17,18] which has been adopted by more and more surgeons. Some other authors, however, believe that, compared to transtibial approach, the anteromedial portal approach has a higher risk of epicondyle cartilage lesion, posterior-femur wall blowout, injury of nervous peroneus communis and is considered to have more difficulty in surgical procedures on patients with obesity.[5]

Posterior wall blowout is not a rare complication in ACL reconstruction via anteromedial portal approach, yet no exact incidence rate is reported. It's a very common hazard that almost every young surgeon of sports medicine may come across. To gain the best anatomic reconstruction, the femoral tunnel is ought to be built close to posterior wall where ACL attachment on femur is very adjacent. However, as the shape of the femur hypocondyle varies among individuals, the operation approach must be from the anterior route. As a result, the femur-tunnel navigator is not guaranteed to be perpendicular to the bone wall which is lateral to the hypocondyle, and may consequently lead to posterior wall blowout.

In such circumstances, many surgeons would take measures as bone tunnel re-drilling, proximal incision or some other fixations in compensation. Inevitably, these measures will increase the duration and cost of operation, as well as an increasing risk of damage. To avoid such incidence, some surgeons will deliberately drill the femoral tunnel more forward. The approach would consequently have negative effect on prognosis, or even cause impingements for the impropriate location of autografts.

Of the 125 patients underwent ACL reconstruction by the corresponding author of our research from 2013 to 2014, 10 presented with such complication. From the author's experience, there is a possibility that we may not necessarily demonstrate femoral incision as long as the autograft is confirmed well fixed in operation. Instead, we can use some other kind of fixations that would not have impact on the surgery, and this may provide young surgeons some constructive suggestions in dealing with such complications.

Some authors used to believe that the posterior wall blowout have negative effects of the operation and would avoid breaking them in practice. Per our observation, there is no evidence suggesting any influence of such complication. For the safety and reliability of surgery, of course, surgeons should try not to break the femur wall, but when such intraoperative complication happen, it may not be necessary to do extra incisions or internal fixations.

There is no statistical difference between patients with posterior wall blowout and the control group in IKDC score, Lysholm score as well as Tegner score, which are the most commonly used scores to assess clinical outcome after ACL reconstruction. So are the rates of Lachman test and Pivot-shift test between the two groups. Compared to the subjective scores and physical examinations, KT-2000 is considered the most objective test of the stability of knee joint. In 30° flextion and 132N tensile force, the average KT-2000 result in control group is higher than broken group, but no significant difference ($P > 0.05$).

In ACL reconstruction, the healing between tendon autograft and bone tunnel is the key factor of operation, affected by method of

fixation, biology factors, physical stimulation and periosteum augmentation at the tendon-to-bone interface.[19] In our study, all patients who had posterior wall blow were treated by endobutton fixation on the lateral side of femoral tunnel. The advantage of such method is that it provides firm fixation regardless whether the patient had osteoporosis or posterior wall blowout. On the other side, when posterior wall is broken, the pattern of healing between autograft and bone tunnel is tendon-to-periosteum healing instead of tendon-to-bone healing. Several studies have reported promising results in periosteum-wrapped tendon on tendon-to-bone healing on animal models.[8,20] A tentative inference is that in the process of healing in patients with posterior wall, there is a possibility of periosteum wrapping and collagen formation between the interface of autograft and bone tunnel. No report, to date, has suggests postponed rehabilitation in patients with posterior wall blowout, and according to our experience, normal procedure of rehabilitation is suitable.

Biodex isokinetic muscle strength test is to assess the rehabilitation of knee joint from measuring muscle strength of knee in different angular velocity. Some authors used to take the absolute value of muscle strength in operational side of knee in research, while we think it is better to compare the deficit percentage in the affected side with unaffected side. According to our study, there is no statistical difference between the broken group and the control group, which means that the rehabilitation in patients with posterior wall blowout is not inferior to the patients without the condition as long as effective fixations were promised in operation. Ma Yong et al.[15] analyzed 110 revision surgeries for instability of knee joint after primary ACL reconstruction. In the 110 cases, too anterior of femoral tunnels is the most common reason (20 cases), followed by too anterior of tibial tunnels (12 cases), too posterior of tibial tunnels (10 cases) and vertical femoral tunnels (7 cases). Only one case of posterior wall blowout was reported as the reason of ACL revision in this study, which suggests this complication have less possibility to cause instability of knee joint.

We used the MRI to evaluate the healing of the tendon autograft 6 months after ACL reconstruction. As mentioned above, there is no statistical difference in SNQ between the two groups. We can assume that the autograft may have the same biomechanical performance, even though the posterior wall breaks, at least within 1 years post operatively.[21]

There were several limitations in this research. The number of patients with such complication is small, and for ethic reasons, we could not break the posterior wall deliberately. We limited the number of participants in control group in order to reduce financial burdens for patients postoperatively. The duration of follow-up was long enough for clinical status and most patients had image, KT and Biodex evaluation at 1 or 2 year post-operatively. However, further study with longer follow-up imaging may be needed to document the sustainability of the effect. In rehabilitation, compliance varies in different patients, which may affect the clinical outcome. Our study is a pilot study with short imaging follow-up and long clinical follow-up. More studies are needed with bigger sample size, longer time of follow-up and more adequate and objective follow-up assessments in the future.

In conclusion, blowout of posterior wall in ACL reconstruction via anteromedial portal will not affect the clinical outcome as long as reliable fixation is performed during operation followed by the standard rehabilitation program.

Funding

Nil.

Ethical statement

This study was approved by the Ethics Committee of Peking University Third Hospital.

Conflict of interest

None.

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