Clinical Results of Double Button Plate Fixation for Posterior Cruciate Ligament Avulsion Fracture

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Research Article

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Abstract

Background The posterior cruciate ligament plays an important role in maintaining the stability of the knee joint. To date, researchers have not reached agreement on which type of fixation material should be used to treat PCL tibial avulsion fractures. The aim of this study was to investigate the effects of double button plate fixation in the treatment of posterior cruciate ligament avulsion fractures. We retrospectively reviewed our database, which was collected prospectively. From January 2019 to January 2020, 33 patients with posterior cruciate ligament avulsion fractures.

Hypothesis To verify the effects of double button plate fixation of PCL avulsion fractures.

Methods Patients with posterior cruciate ligament avulsion fractures were treated with double button plate fixation. The primary outcomes of this study were surgical complications (fixation failure/displacement, implant breakage, nonunion, infection), radiological parameters, and knee function. Secondary outcomes included reoperation rates for the fixation methods and the prevalence of symptomatic hardware causing soft tissue irritation.

Results The results showed that double button plate fixation have no incidence of complications and can recovery postoperative range of motion (ROM), Knee Society Score (KSS) function and Lysholm scores.

Conclusion The use of double button plate fixation technology has the following advantages: less trauma, shorter operation time, convenient use of instruments and fixtures, and it does not need to be taken out again, thus avoiding secondary trauma. Moreover, the strength of the suture is large, and the tension of the posterior cruciate ligament can be fully reduced by tying the suture band. Double button plate fixation under direct vision is safe and reliable without the need for additional equipment. Even comminuted fractures can also be effectively fixed by knotting. Our results suggest that this technique is a reliable and useful alternative treatment for irreparable rotator cuff tears.

Level of Evidence: Case-control study, Level III.

Background

The posterior cruciate ligament plays an important role in maintaining the stability of the knee joint[1]. In general, simple PCL injury is not common, and tibial avulsion fracture is the most common type. It has been reported that avulsion fracture of the tibial insertion is common in young people. The main causes of avulsion fractures are traffic accidents and falling injuries during strenuous exercise[2]. The damage mechanisms usually include overflexion, anteroposterior and hyperextension. PCL tibial avulsion fracture is a special type of PCL injury, accounting for approximately 10% of all PCL injuries[2,3]. In the past, due to insufficient understanding and limited examination instruments, misdiagnosis and missed diagnosis led to untimely treatment, poor treatment effect, a high risk of fracture displacement, delayed union and nonunion, and the dysfunction of the knee joint in later stages[4].

The treatment of PCL tibial avulsion fractures includes nonoperative treatment, traditional open reduction internal fixation, and arthroscopic surgery[5]. Open surgery has been widely carried out, and the main internal fixation materials include absorbable screws, cannulated screws, and anchors with threads. Cannulated screw fixation has high fixation strength and stability, but all the stress is concentrated in the tail of the screw, which easily causes re-fracture and leads to internal fixation failure; at the same time, the huge tension of the PCL during knee joint movement may lead to higher risks of re-fracture and fracture block displacement, limiting early functional exercise and increasing complications. Arthroscopic internal fixation can complete the exploration of the knee joint through several small incisions and monitor the operation in the process of drilling the tunnel or screw placement. It has the advantages of minimal surgical trauma and fast patient recovery but also features high technical requirements for surgeons, a long learning curve, high requirements for equipment, and requirements for expensive equipment[6]. At present, open surgery and internal fixation are still mainstream. The appearance of internal fixation materials gives surgeons more choices. They can fix the fracture block directly through the posterior small incision.

Internal fixation methods have many disadvantages, such as insufficient fixation strength, high tension on the cruciate ligament and long-term immobilization, which to some extent affect early postoperative rehabilitation exercise, resulting in knee joint adhesion, flexion and extension function limitations and other shortcomings[7]. An alternative is to utilize double button plate fixation methods. We adopted double button plate fixation in the management of posterior cruciate ligament avulsion fractures. To date, researchers have not reached an agreement on which type of fixation material should be used to treat PCL tibial avulsion fractures. Therefore, this study aimed to evaluate the associations of perioperative and postoperative outcomes of double button plate[3].

Methods

Patients

We retrospectively reviewed our database, which was collected prospectively. From January 2019 to January 2020, 33 patients with posterior cruciate ligament avulsion fractures underwent surgery by a single surgeon. The patients signed an informed consent form approved by the Institutional Review Board at our hospital (Tianjin First Center Hospital). The clinical data of 33 patients with regular follow-up were obtained, with 20 males and 13 females. The inclusion criterion was a single avulsion fracture of the posterior cruciate ligament, the time of injury was less than 3 weeks, all patients had complete imaging examination of the knee joint, with a positive posterior drawer test and Lachman test, and they were type II and type III according to the Meyers classification. The exclusion criteria included combined tibial plateau fractures, fractures around the knee joint, comminuted fracture, pathological fracture, Meyers type I, anterior and posterior cruciate ligament injuries, medial and lateral collateral ligament injuries, and combined severe vascular and nerve injuries. Traffic accidents were the major mechanism of injury, accounting for 18 (55%) of 33 cases, along with 13 cases of fall injury (39%) and 2 cases of injury involving accidental sprains (6%) (Table 1).

Table 1 Summary of Patients

Knee	Sex	Age (year)	Job	Meyers classification	Injury	Operation
1	M	55	Manual worker	Type II	Traffic accident	Primary
2	F	59	Housewife	Type II	Traffic accident	Primary
3	M	61	Manual worker	Type II	Fall	Primary
4	M	58	Housewife	Type II	Traffic accident	Primary
5	M	59	Farmer	Type III	Fall	Primary
6	F	64	Housewife	Type III	Traffic accident	Primary
7	F	61	Housewife	Type III	Fall	Primary
8	M	56	Manual worker	Type II	Fall	Primary
9	M	59	Farmer	Type II	Traffic accident	Primary
10	M	58	Farmer	Type III	Accidental sprains	Primary
11	F	59	Housewife	Type II	Traffic accident	Primary
12	M	55	Desk work	Type II	Traffic accident	Primary
13	F	59	Farmer	Type II	Fall	Primary
14	M	61	None	Type II	Traffic accident	Primary
15	M	54	Farmer	Type II	Fall	Primary
16	F	58	None	Type II	Traffic accident	Primary
17	F	52	Desk work	Type II	Fall	Primary
18	M	59	Farmer	Type II	Traffic accident	Primary
19	F	58	None	Type II	Fall	Primary
20	M	56	Farmer	Type II	Traffic accident	Primary
21	M	57	Manual worker	Type II	Fall	Primary
22	M	54	Desk work	Type II	Traffic accident	Primary
23	F	53	Desk work	Type II	Fall	Primary
24	M	58	Manual worker	Type III	Traffic accident	Primary
25	M	58	Farmer	Type III	Traffic accident	Primary
26	F	57	None	Type III	Traffic accident	Primary
27	M	63	Manual worker	Type III	Fall	Primary

28	F	57	Housewife	Type III	Traffic accident	Primary
29	M	58	Manual worker	Type III	Fall	Primary
30	F	51	Desk work	Type III	Traffic accident	Primary
31	M	59	Farmer	Type II	Traffic accident	Primary
32	M	60	Manual worker	Type III	Fall	Primary
33	M	59	Manual worker	Type II	Accidental sprains	Primary

Abbreviations: M, male; F, female;

The patients provided a standard history and underwent physical examination that consisted of measurement of the knee range of motion ,KSS function scores and Lysholm scores by a single surgeon before surgery; at 3, 6, and 12 months after surgery; and yearly thereafter.

Radiography and Magnetic Resonance Imaging

We obtained preoperative and follow-up radiographs in all patients. Magnetic resonance imaging (MRI) was performed with a 3.0-T closed-type scanner (MRT-2000/V2,Tianjin,China). Oblique coronal, oblique sagittal, and axial T2-weighted MR images were acquired for structural and qualitative assessment of the posterior cruciate ligament, and repair integrity was determined. Radiography and MRI were performed by a single surgeon before surgery; at 3, 6, and 12 months after surgery; and yearly thereafter, and this study used the final data. Average follow-up was 14 months (range, 12 to16 months) after surgery.

Surgical Technique

We performed surgery using general anaesthesia with patient in the prone position, and the injury leg was bound with a tourniquet. We examined knee range of motion and positive posterior drawer test and Lanchman test with the patient under general anesthesia. A 6-cm-long longitudinal incision was made, and the posterior edge of the tibia was exposed. After reduction, Kirschner wire was used for temporary fixation, a bone canal was established , and double button plate fixation was used for compression fixation. During the operation, the fracture was stable through passive movement. Physical examination showed that the knee joint was stable. X-ray fluoroscopy showed that the fracture was well reduced and fixed, and the position of the titanium plate was acceptable (Figure 1, Figure 2). The limb was fixed with plaster at 10 degrees of extension.

Postoperative Protocol

Postoperative radiographs were taken after surgery. Patients were given a plaster as protection postoperatively. In general, 0 to 90 degrees of flexion in the brace was allowed for the first 2 weeks postoperatively. Patients were given their first follow-up appointment at 2 weeks postoperatively for wound inspection, and then they were followed up every 2 to 4 weeks to monitor for functional return and

clinical/radiological fracture union. The knee joint activity gradually strengthened by the fourth week after the operation, the passive flexion activity was 120°, and some weight-bearing walking began at the sixth week after the operation. Weight-bearing walking was completely carried out 8 weeks after the operation, and the injured state was essentially restored at 12 weeks after the operation.

Statistical Analysis

Data were analyzed using SPSS 13.0 software (SPSS, Chicago, IL, USA). All data were reported as the mean±standard deviation (SD). One-way ANOVA was employed for all statistical analyses, followed by Student-Newman-Keul’s test. Values were compared using multiple comparisons, where p-values of 0.05 or less were considered significant.

Results

Mean operation time and average bleeding loss were recorded (Table 1). The primary outcomes of this study were surgical complications (fixation failure/displacement, implant breakage, nonunion, infection), radiological parameters, and knee function. Secondary outcomes included reoperation rates for the fixation methods and the prevalence of symptomatic hardware causing soft tissue irritation.

At 2 weeks after the operation, the plaster was removed, all patients had normal flexion and extension of the knee joint at 6-8 weeks, and 3 months after the operation, the fracture had reached the healing standard. Functional outcome was assessed by means of walking status, range of motion, and KSS function and Lysholm scores upon final follow-up (Table 2, Figure 3). Overall, average time to final follow-up was 20 months (range, 16 to 24months), and the fractures had healed 3 months after the operation. There were no neurovascular fractures or infections. Follow-up X-rays showed that the avulsion fracture fragments of the tibial attachment point of the posterior cruciate ligament healed well, and there was no displacement or implant breakage of the fracture fragments (Table 3).

Table 2. Summary of Patients’Knee Functional Scores

Knee	KSS function (scores)		Lysholm (scores)		ROM (degree)	
	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
1	40	95	40.5	91.5	0-40	0-120
2	45	98	41.5	92.5	0-45	0-120
3	35	90	38.5	90.5	0-35	0-120
4	50	100	41.5	100	0-40	0-130
5	55	100	42.5	100	0-45	0-130
6	45	98	40.5	96.5	0-40	0-125
7	40	100	40.5	100	0-45	0-130
8	35	92	36.5	89.5	0-40	0-120
9	40	95	40.5	90.5	0-45	0-125
10	45	98	42.5	92.5	0-40	0-125
11	40	90	40.5	92.5	0-45	0-120
12	40	91	40.5	91.5	0-40	0-125
13	45	95	41.5	92.5	0-45	0-125
14	35	92	38.5	90.5	0-35	0-115
15	50	100	41.5	100	0-40	0-130
16	55	100	42.5	100	0-45	0-130
17	45	95	40.5	91.5	0-40	0-120
18	40	90	40.5	92.5	0-45	0-120
19	35	92	36.5	89.5	0-40	0-120
20	40	90	40.5	90.5	0-45	0-125
21	45	90	42.5	92.5	0-40	0-125
22	40	90	40.5	92.5	0-45	0-120
23	40	90	40.5	91.5	0-40	0-125
24	45	95	41.5	92.5	0-45	0-125
25	35	92	38.5	90.5	0-35	0-115
26	50	100	41.5	100	0-40	0-130
27	55	100	42.5	100	0-45	0-130

28	45	95	40.5	91.5	0-40	0-130
29	40	95	40.5	92.5	0-45	0-120
30	35	92	36.5	89.5	0-40	0-120
31	40	90	40.5	90.5	0-45	0-125
32	45	90	42.5	92.5	0-40	0-125
33	40	92	40.5	92.5	0-45	0-120

Abbreviations: ROM, Range of motion; KSS, Knee Society Score;

Table 3. Summary of Patients'Complication

Knee	FWB (weeks)	Nonunion	Any infection	Revision	Implant removal
1	10	N0	N0	N0	N0
2	11	N0	N0	N0	N0
3	11	N0	N0	N0	N0
4	12	N0	N0	N0	N0
5	10.5	N0	N0	N0	N0
6	11	N0	N0	N0	N0
7	11.5	N0	N0	N0	N0
8	12	N0	N0	N0	N0
9	11	N0	N0	N0	N0
10	12	N0	N0	N0	N0
11	11.5	N0	N0	N0	N0
12	11	N0	N0	N0	N0
13	12	N0	N0	N0	N0
14	11	N0	N0	N0	N0
15	12	N0	N0	N0	N0
16	10.5	N0	N0	N0	N0
17	11	N0	N0	N0	N0
18	11.5	N0	N0	N0	N0
19	12	N0	N0	N0	N0
20	11	N0	N0	N0	N0
21	12	N0	N0	N0	N0
22	11.5	N0	N0	N0	N0
23	11	N0	N0	N0	N0
24	12	N0	N0	N0	N0
24	11	N0	N0	N0	N0
26	13	N0	N0	N0	N0
27	10.5	N0	N0	N0	N0
28	11	N0	N0	N0	N0

29	11.5	NO	NO	NO	NO
30	12	NO	NO	NO	NO
31	11	NO	NO	NO	NO
32	12	NO	NO	NO	NO
33	11.5	NO	NO	NO	NO

Abbreviations: FWB, full weight bearing;

Discussion

The tension of the PCL is highest in the flexion position of the knee joint, and tibial avulsion fracture mainly occurs in knee flexion. In the flexion position, the lateral condyle of the femur moves backward, and the femur rotates outwards. The force from front to back causes the posterior tibia to be impacted by the femoral condyle, and the tension of the PCL increases sharply, which eventually leads to avulsion fracture of the PCL tibial insertion point[8]. Because the contact area between the posteromedial tibia and the medial femoral condyle is larger than that between the posterolateral tibia and the lateral femoral condyle, PCL tibial avulsion fracture fragments are increasingly larger. If not intervened, they can seriously affect the stability of the posterior part of the knee joint, and the fracture block protrudes behind the tibial intercondylar ridge, which may induce impingement syndrome[9]. In the late stage, quadriceps atrophy, joint effusion, articular cartilage degeneration and secondary meniscus injury can become aggravated, which will seriously affect the quality of life of patients. Therefore, the current view is that PCL tibial avulsion fractures should be firmly fixed to avoid postoperative displacement or poor healing, resulting in the instability of the knee joint [10].

There are many kinds of surgical methods for PCL tibial avulsion fracture, including arthroscopic and open surgical approaches. Arthroscopic surgery has the advantages of minimal trauma, a small amount of soft tissue damage and fast recovery. However, in most total arthroscopic surgeries, a bone tunnel must be drilled on the tibia. The tunnel introduces an internal fixator through the tunnel, which has the characteristics of complex operation, high equipment requirements and a long learning time, limiting its development [11]. Open surgery for PCL tibial avulsion fractures has been widely carried out. The internal fixation materials mainly include steel wires, absorbable screws, hollow screws, Kirschner wires, and wire anchors. Steel wire fixation is convenient and economical, but it easily causes further fracture of the fracture block in the process of the operation, causing secondary damage to the blood supply of the fracture block and affecting fracture healing; moreover, to avoid the fracture of the steel wire after the operation, long-term bracing is necessary, resulting in limited joint function and joint stiffness[12]. The absorbable screw material can be absorbed after the operation, and it is unnecessary to remove the internal fixator, avoiding a secondary operation and trauma. However, the external fixation time of absorbable screws, such as plasters or braces, is long, and 4~6 weeks of fixation is advocated. At the same time, absorbable screws have low strength and are characterized by weak fixation and easy

displacement[13]. Simple cannulated screw fixation has high fixation strength and stability, but all the stress is concentrated in the screw tail, which easily leads to stress concentration, refracture and internal fixation failure[14].

Due to comminuted fracture, small bone fragments are often difficult to fix, but early rehabilitation exercise requires relatively stable fixation. For the treatment of this kind of fracture, in addition to conventional surgical methods such as tension band steel wire fixation, purse suture fixation and special plate fixation are also currently commonly used. For patients with posterior cruciate ligament avulsion fracture and repair difficulties, a more classic treatment method is to insert two button plates into the broken end of the fracture. The sutures are sewn out along the aponeurosis, and then the two circuits are sewn and knotted with each other. With a button plate, the fracture block is fixed reliably, the fracture surface is in good contact, and the PCL is connected by a nonabsorbable tension suture. This method can reduce any large movement of the fracture block during knee joint functional exercise, disperse the concentrated stress around the button plate during knee joint flexion, reduce the risk of refracture, promote fracture healing and avoid joint adhesion complications[15,16].

The use of double button plate fixation technology has the following advantages: less trauma, shorter operation time, convenient use of instruments and fixtures, and it does not need to be taken out again, thus avoiding secondary trauma. Moreover, the strength of the suture is large, and the tension of the posterior cruciate ligament can be fully reduced by tying the suture band. Double button plate fixation under direct vision is safe and reliable without the need for additional equipment. Even comminuted fractures can also be effectively fixed by knotting.

Limitations

There are also shortcomings in this study, such as small sample size , which may lead to deviations in the evaluation of curative effect. Further expansion of sample size and long-term follow-up are needed to confirm this.

Conclusion

In this study, double button plate fixation technology for the treatment of posterior cruciate ligament avulsion fractures has the advantages of minimal trauma, simple operation, reliable fixation and a large fracture contact area, fewer postoperative complications, and restored stability and function of knee joints. Our results suggest that this reconstruction technique is a reliable and useful alternative treatment.

Declarations

Ethical Approval and Consent to participate

The study was approved by the institutional review board of Tianjin First Center Hospital. All authors and patients have read and approved the final manuscript.

Consent for publication

All authors have read and approved the final manuscript.

Availability of data and materials

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Kai Sun designed the study protocol, participated in the data analysis, and drafted the manuscript. Meng Fan participated in the analysis and revision of the manuscript. All authors have read and approved the final manuscript.

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References

1. MutchameeS, GanokrojP. Arthroscopic Transosseous Suture-bridge Fixation for Anterior Cruciate Ligament Tibial Avulsion Fractures[J]. Arthrosc Tech, 2020, 9(10): e1607-e1611.
2. GilmerBB. Editorial Commentary: Anterior Cruciate Ligament Tibial Eminence Avulsion Fractures: Are They Trying to Tell Us Something[J]. Arthroscopy, 2019, 35(5): 1545-1546.
3. LeieM, HeathE, ShumborskiS. Midterm Outcomes of Arthroscopic Reduction and Internal Fixation of Anterior Cruciate Ligament Tibial Eminence Avulsion Fractures With K-Wire Fixation[J]. Arthroscopy, 2019,35(5):1533-1544.
4. ShenFX, DuWB, ChenRL, et al. High strength wire under arthroscopy combined with outside anchor nail in treating Meyers McKeever II, III avulsion fracture of anterior cruciate ligament tibial check point[J]. Zhongguo Gu Shang, 2019, 32(11): 1034-1037.
5. Dong, Wang, Kai, et al. Mini-plate versus Kirschner wire internal fixation for treatment of metacarpal and phalangeal fractures.[J].The Journal of international medical research, 2019:2147483647-

2147483647.

6. Marom N, Ruzbarsky JJ, Boyle C, Marx RG. Complications in Posterior Cruciate Ligament Injuries and Related Surgery. *Sports Med Arthrosc Rev.* 2020, 28(1):30-33.
7. Kew ME, Miller MD. Posterior Cruciate Ligament Reconstruction in the Multiple Ligament Injured Knee. *J Knee Surg.* 2020, 33(5):421-430.
8. LeebergV, Lekdorf J, Wong C, et al. Tibial eminencia avulsion fracture in children a systematic review of the current literature [J]. *Dan Med J.* 2014, 61(3):A4792.
9. Chen LB, Wang H, Tie K, et al. Arthroscopic fixation of an avulsion fracture of the tibia involving the posterior cruciate ligament: A modified technique in a series of 22 cases [J]. *Bone Joint J.* 2015, 97B(9):1220-5.
10. Meng Fan, Dong Wang, Kai Sun, Wenxue Jiang. Study of double button plate fixation in treatment of inferior pole of patella fracture. *Injury.* 2020; 51(3):774 - 8
11. Schlumberger M, Schuster P, Eichinger M, Mayer P, Mayr R, Immendörfer M, Richter J. Posterior cruciate ligament lesions are mainly present as combined lesions even in sports injuries. *Knee Surg Sports Traumatol Arthrosc.* 2020, 28(7):2091-2098.
12. Sabat, D, Jain, A, Kumar, V. Kumar. Displaced Posterior Cruciate Ligament Avulsion Fractures: A Retrospective Comparative Study Between Open Posterior Approach and Arthroscopic Single-Tunnel Suture Fixation. *Arthroscopy.* 2016, 32(1), 44-53.
13. Bouras T, Fennema P, Burke S, et al. Stenotic intercondylar notch type is correlated with anterior cruciate ligament injury in female patients using magnetic resonance imaging [J]. *Knee Surg Sports Traumatol Arthrosc.* 2018, 26(4): 1252-1257.
14. Zhang C, Xie G, Dong S, et al. A novel morphological classification for the femoral notch based on MRI: a simple and effective assessment method for the femoral notches [J]. *Skeletal Radiol.* 2020, 49(1): 75-83.
15. Bernhardtson AS, DePhillipo NN, Daney BT, et al. Posterior tibial slope and risk of posterior cruciate ligament injury [J]. *Am J Sports Med.* 2019, 47(2): 312-317.
16. van Kuijk KSR, Reijman M, Bierma-Zeinstra SMA, et al. Posterior cruciate ligament injury is influenced by intercondylar shape and size of tibial eminence [J]. *Bone Joint J.* 2019, 101-B(9): 1058-1062.

Figures

a

b

Figure 1

Preoperative radiograph of posterior cruciate ligament (PCL) avulsion fracture

PCL avulsion fracture of a 55-year-old male was fixed with double button plate

a, CT showed the tibial intercondylar eminence fracture. b MRI confirmed the fragment size and displacement of the PCL avulsion fracture. Fragment involved the medial and lateral tibial plates.

Figure 2

Intraoperative radiograph of double button plate fixation

Figure 3

Postoperative radiograph of double button plate fixation (4 months)