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Original Article

Risk factors of traumatic knee osteoarthritis after arthroscopic surgery treated tibial plateau fractures

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Abstract: Aim: We aimed to investigate the risk factors of traumatic knee osteoarthritis (OA) after arthroscopic surgery treated tibial plateau fracture (TPF) and the prognostic factors of the surgery. Methods: Between January 2012 and January 2013, a total of 59 TPF patients received arthroscopic surgery in Yiwu Central Hospital, Affiliated Hospital of Wenzhou Medical University was enrolled in this study. Patients were divided into the concurrent group and the non-concurrent group according to whether patients were complicated by traumatic knee OA or not. Related influenced factors of secondary traumatic knee OA were explored via single factor and multivariate logistic regression analyses. The knee functional scores in the last follow-up were regarded as prognostic indicators. Single factor and ordinal logistic regression analyses were applied for investigating factors associated with prognosis. Results: All patients received 2-years follow-up, and 20 cases were complicated by traumatic knee OA. Significant difference in comparison of age, BMI, history of knee OA, fracture typing, associated injury around the knee, reset conditions after surgery and the time from injury to treatment between the concurrent and non-concurrent groups (all $P<0.05$). Multivariate analysis showed that age, history of knee OA, associated injury around the knee and reset conditions after surgery had significant effects on the secondary traumatic knee OA, and the odds ratios were 1.16, 15.16, 7.12 and 0.08, respectively. Single factor analysis of prognosis revealed that age, fractures typing, reset conditions after surgery, the time from injury to treatment, and secondary traumatic knee OA all had effect on scores of knee function (all $P<0.05$). Ordinal logistic regression analysis found significant difference in IV type, associated injury around the knee, traumatic knee OA and reset conditions after surgery, and odds ratios of knee functional scores were 5.76, 12.30, 18.10 and 0.21, respectively. Conclusion: Independent risk factors of traumatic knee OA after arthroscopic surgical management of TPF were age, history of knee OA, and associated injury around the knee, while, excellent-good results of fractures reduction was independent protective factor. Fracture typing, associated injury around the knee and traumatic knee OA were risk factors of prognosis, and excellent-good results of fractures reduction was protective factor.

Keywords: Arthroscopic surgery, tibial plateau fracture, traumatic knee osteoarthritis, knee functional score, logistic regression analysis, prognosis

Introduction

Tibial plateau fracture (TPF) is a bone fracture or break in the continuity of the bone occurring in the proximal part of the tibia or shinbone called the tibial plateau; affecting the knee joint, stability and motion. Statistic showed that TPF account for approximately 10% fractures in elderly and 1% in the general population with a peak age of 30~40 years old in men and 60~70 years old in women [1, 2]. Patients with TPF may typically presents with knee effusion, swelling of the knee soft tissues and inability to bear weight. And the classification of tibial plateau fractures has been historically based on anteroposterior radiographs, without consideration of bicondylar coronal fracture lines and resulting sagittal plane [3-5]. TPFs can be seen markedly in two groups of people: younger people with higher-energy injuries and elderly people with lower-energy fractures [6]. To the best of our knowledge, the mechanism of TPF is a combination of valgus or varus force, direct axial compression and indirect shear forces with knee in flexion [7]. The features of TPFs range from simple to complex, with little or extensive articular involvement and treatment with open reduction and internal fixation can be difficult [8, 9].

Arthroscopic surgery is a procedure that an arthroscope was inserted into the knee joint with lavage to remove particulate material, including calcium crystals and cartilage fragments [10]. Knee arthroscopy is now mainly applied for meniscal transplantation, arthroscopically assisted ligament reconstruction as well as synovectomy, and treating conditions like meniscal tears and cartilage flaps debridement, loose bodies removal and cartilage flaps recontouring [11]. Previous evidence revealed that arthroscopic surgery in treating TPFs with associated soft-tissue injuries is a safe and effective procedure, which can provide precise diagnosis and effective treatment in a 1-stage procedure [12]. While, traumatic knee osteoarthritis (OA) was deemed as one of the most common complication occurred after arthroscopic surgery treated TPFs, with more than 12% of the cases of symptomatic OA [13]. OA was demonstrated to lead to pain, swelling, stiffness, muscle weakness and joint instability, all of which can result in impairment of physical function and decline of life quality [14]. Considering the complication of traumatic knee OA caused by arthroscopic surgery for the treatment of TPFs and the damages of traumatic knee OA, we conducted this study to further investigate risk factors of traumatic knee OA after arthroscopic surgery treated TPF and the prognostic factors of the surgery.

Materials and methods

Ethical statement

This study was approved by the Ethical Committee of Yiwu Central Hospital, Affiliated Hospital of Wenzhou Medical University. Written informed consents were obtained from all study subjects. This study complied with the guidelines and principles of the Declaration of Helsinki [15].

Study subjects

Between January 2012 and January 2013, a total of 59 patients (males: n = 34; females: n = 25; age: 25~70 years old; mean age: 45.73 ± 9.40 years old) with TPF diagnosed in our hospital were enrolled in our retrospective prospective cohort study. The Schatzker typing were: 3 cases were type I, 5 cases were type II, 3 cases were type III, 16 were type IV, 15 were type V, 17 were type VI, 15 were meniscus injury, 6 were cruciate ligament injury, and 9 were side ligament injury. Patients might be enrolled with the following items: (1) patients diagnosed with closed fracture of tibial plateau; (2) patients received the treatment of arthroscopic surgery; (3) patients had complete baseline characteristics and follow-up information. The exclusion criteria were: (1) patients had vascular and nerve injuries, open and obsolete fractures, and fractures in other parts; (2) patients had severe liver, kidney, cardiovascular and neurological disorders. Patients had complication of traumatic knee osteoarthritis (OA) after surgery was included the concurrent group (n = 20), otherwise, patients were enrolled in the non-concurrent group (n = 39). Forty-three patients had a time of less than 14 d from injury to surgery, and the remaining had a time of more than 14 d. The deadline of follow-up was range from January 2014 to January 2015, and the follow-up time of all patients was two years.

The diagnostic criteria of traumatic knee OA were based on American College of Rheumatogy (ACR) 1995 recommendations [16]: (1) gonalgia occurred in the most of the time of preceding month; (2) existed bony crepitus; (3) early morning stiffness <30 min; (4) age >38 years old; (5) bony enlargement; (6) formation of osteophyte can be seen in X-ray. Patients were diagnosed with traumatic knee OA if they had above-mentioned phenomena as described in 1+2+3+4, 1+4+5 or 1+6.

Surgical methods

Epidural anesthesia or general anesthesia was applied for patients. Knee arthroscopy (Stryker company, USA) was used for articular cavity exploration via medial and lateral standard incisions of knee anterior. The fracture shape, shift position of bone block, the extent of cartilage damage in fracture block, meniscus injury or not, and cruciate ligament injury were checked. And the I phrase of repair would be conducted when patients had complete rupture of medial collateral ligament, I~II phrase of ligament reconstruction would be conducted when patients had cruciate ligament injury. Patients had meniscus injury may receive excision or suture.

Fracture reduction and methods of internal fixation were selected based on the fracture typing: I type: fracture blocks were reset via pushing fracture block and flexion of joint to reset, and then a number of Kirschner wires were drilled into to fix fracture block. After the confirmation of C-arm X-ray device via lateral position, bone screws were screwed with the Kirschner wires. II~IV types: the fracture blocks were fixed by unilateral steel plate, and positioned by cruciate ligament guider. Guide pin was unthreaded from site of platform collapse which was deviated from fracture line. Bone tunnel was established along with guide pin by hollow boring bit (do not unthread the cartilage surface). Subsidence area was knocked slightly via self-made round bar, and pressed to reset. After autogenous bone or artificial bone was implanted into bone tunnel, tibial plateau was checked by C-arm X-ray device. After the reduction is good, the bone screw was inserted along with the guide pin, followed by steel plate fixation. V~IV types: the fracture blocks were fixed by bilateral steel plate. Incisions were conducted in medial and lateral of anticustibialis, which extended to extra periosteal. Soft tissue tunnel was established in distal along the vertical axis of tibia, and then steel plate was crossed from tunnel to fracture site, followed by temporary fixation by Kirschner wires. C-arm X-ray device was used for checking the fracture reduction. After satisfactory reduction, steel plate was fixed according to extracutaneous fixation method and holes were fixed via screw.

Postoperative management

Elevated affected extremity and pressure dressing combined with ice compress were conducted after surgery to achieve hemostasis in bleeding and pain relief. On the next day after surgery, patients can conduct contraction exercise, like quadriceps exercise, for preventing muscle atrophy, and passive activity of knee can also be conducted under protection. One week after surgery, continuous passive motion (CPM) can be used for exercising knee, and rehabilitation training was conducted according to personal information. X-ray conducted after surgery was applied for reexamining the conditions of fracture reduction and healing. Loaded walking of affected extremity with the help of crutch can be conducted under accompany of nurse when callus was formed obviously. Generally, a large number of calluses were formed after 2~3 months, so loaded walking of affected extremity without the help of crutch can be conducted by patients.

Outcome measures

X-ray was taken after internal fixation and before dismantlement of internal fixation. For the evaluation of anatomical reduction of TPFs, patients were graded according to the extent of collapse of articular surface, platform broadening, and angular deformity. Collapse of articular surface: 6 points for a depth of 0 mm; 4 points for a depth of <5 mm; 2 points for a depth of 6~10 mm; 0 point for a depth >10 mm. Platform broadening and angular deformity had the same evaluation standards as collapse of articular surface, and total points of 18 points were regarded as excellent, 12~17 points were good, 6~11 points were average, and 0~5 points were poor. Besides, the baseline characteristics were recorded, including patients' age, gender, body mass index (BMI), history of knee OA, family history of OA, labor intensity, smoking and drinking. Patients were observed for whether there were other complications occurred or not during follow-up.

Evaluation of knee function

Rasmussen knee score system [17] was used for evaluation of knee function of patients receiving the last follow-up, and this evaluation was also regarded as indicator for prognostic analysis. Patients with a score ≥27 points were regarded as excellent, 20~60 points were good, 10~19 were average, and 6~9 were poor. Among all scores, satisfactory result was patients with ≥20 points, while, patients with <20 points were deemed as unsatisfactory results.

Statistical analysis

Stata 12.0 software was used for data analysis. Continuous variables and unordered categories variables were analyzed via t-test and chi-square test, respectively. Unidirectional ordered categorical variables were analyzed by Cochran-Mantel-Haensel Statistics (CMH). Multivariate analysis was conducted via binary logistic regression and ordinal logistic regression analysis. P<0.05 was considered as statistically significant.

Table 1. Baseline characteristics of the concurrent and non-concurrent groups

	The concurrent group (n = 20)	The non-concurrent group (n = 39)	t/χ^2	P
Age	50.60 ± 9.48	43.23 ± 8.43	3.046	0.004
Gender: male (n, %)	13 (65.0)	21 (53.8)	0.674	0.412
BMI	27.15 ± 4.05	23.92 ± 5.22	2.419	0.019
History of knee OA (n, %)	8 (40.0)	3 (7.7)	9.098	0.003
Family history of OA (n, %)	2 (10.0)	5 (12.8)	0.101	0.751
Labor intensity (n, %)			3.127	0.372
Mental work	3 (15.0)	10 (25.6)		
Stage I of labor intensity	12 (60.0)	19 (48.7)		
Stage II of labor intensity	4 (20.0)	10 (25.6)		
Stage III of labor intensity	1 (5.0)	0 (0.0)		
Smoking (n, %)	7 (35.0)	10 (25.6)	0.565	0.452
Drinking (n, %)	6 (30.0)	8 (20.5)	0.658	0.417
Fracture typing (n, %)			8.325	0.04
I~III types	2 (10.0)	9 (23.1)		
IV type	2 (10.0)	14 (35.9)		
V type	8 (40.0)	7 (18.0)		
VI type	8 (40.0)	9 (23.1)		
Associated injury around the knee (n, %)	14 (60.0)	8 (25.6)	13.846	<0.001
Reset conditions after surgery (n, %)			10.78	0.001
Average and poor	14 (70.0)	10 (25.6)		
Excellent and good	6 (30.0)	29 (74.4)		
Time from injury to treatment (n, %)			4.895	0.027
≥14 d	9 (45.0)	7 (18.0)		
<14 d	11 (55.0)	32 (82.0)		
Other postoperative complications (n, %)	8 (40.0)	10 (25.6)	1.286	0.257

BMI: body mass index; OA: osteoarthritis.

Table 2. Multivariate logistic regression analysis of traumatic knee OA

Influencing factors	B	SE	*P* value	OR	95% CI
Age	0.15	0.06	0.013	1.16	1.03~1.31
History of knee OA	2.72	1.08	0.012	15.16	1.81~126.80
Associated injury around the knee	1.96	0.92	0.032	7.12	1.19~42.89
Reset conditions after surgery	-2.49	0.99	0.012	0.08	0.01~0.58

OA: osteoarthritis; B: partial regression coefficient; SE: standard error; OR: odd ratio; 95% CI: 95% confidence interval.

Results

Baseline characteristics of the case and control groups

Table 1 showed the baseline characteristics of the concurrent and non-concurrent groups. The result revealed a significant difference in comparison of age, BMI, history of knee OA, fracture typing, associated injury around the knee, reset conditions after surgery and the time from injury to treatment between the concurrent and non-concurrent groups (all P<0.05), while, no such difference was found in comparison of the remaining factors between the concurrent and non-concurrent groups (P>0.05).

Multivariate analysis of traumatic knee OA

All factors were included in binary logistic regression analysis. Forward step-wise selection method was applied for selecting variables (P = 0.05: inclusion; P = 0.01: exclusion). Age, history of knee OA, associated injury around the knee and reset conditions after surgery were found to be correlated with whether secondary traumatic knee OA would happen after surgery or not. Age, history of knee OA, and associated injury around the knee were deemed

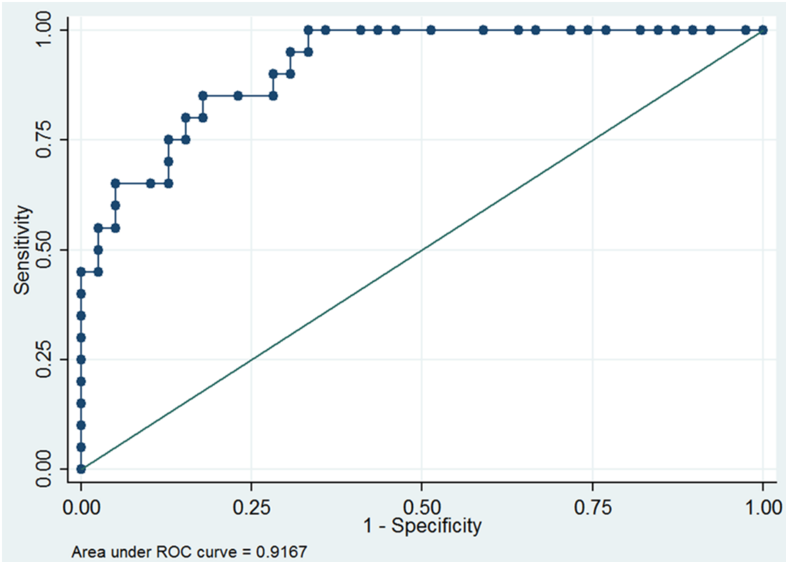

Figure 1. Receiver operating characteristic curve (ROC) of binary logistic regression analysis.

Multivariate analysis of prognosis of TPF

Ordinal logistic regression analysis was conducted by knee functional score were ordered variables. Forward step-wise selection method was applied for selecting variables (P = 0.05: inclusion; P = 0.01: exclusion). Fractures typing, associated injury around the knee and reset conditions after surgery and traumatic knee OA were selected as variables that have significant meaning. The odds ratio of patients with IV type named average and poor scores had 5.76 times as much as that in patients with I~III types named good, average and poor scores, while, patients with associated injury around the knee and traumatic knee OA had 12.30 and 18.10 times, respectively, as much as that in patients without them. And odds ratio of patients with excellent and good scores of fracture reduction had 0.21 times as much as that in patients with average and poor scores. Fractures typing, associated injury around the knee and traumatic knee OA were risk factors of knee function after surgery, and excellent and good scores of fracture reduction were protective factors of knee function (as shown in **Table 4**).

as risk factors with the increased odds rates of 1.16, 15.16 and 7.12 times, respectively. While, reset conditions after surgery was the protective factor, and the odds ratio in patients with excellent reset was 0.08 times as much as that in patients with average and poor reset (as shown in **Table 2**). **Figure 1** showed the receiver operating characteristic curve (ROC) of binary logistic regression model, and the area under curve (AUC) was 0.9167 (95% CI = 0.85~0.98), suggesting a better predictive value of this model.

Related characteristics of prognosis of TPF

Knee function was scored in the last follow-up, and 26 cases were regarded as excellent, 18 cases were good, 8 were average and 7 were poor. Due to the relatively small people in patients with average and poor conditions, these two groups were combined into one group to receive analysis. Result of single factor analysis showed that age, fractures typing, reset conditions after surgery, the time from injury to treatment, and secondary traumatic knee OA all had effect on scores of knee function, with the *P* values of 0.010, 0.031, 0.014, 0.012 and 0.003, respectively. Other factors had no significant effect on scores of knee function (all P>0.05). Details were shown in **Table 3**.

Discussion

The present study provides the evidence that independent risk factors of traumatic knee OA after arthroscopic surgery treated TPFs were age, history of knee OA, and associated injury around the knee, while, excellent-good results of fractures reduction was independent protective factor. Fracture typing, associated injury around the knee and traumatic knee OA were risk factors of prognosis, and excellent-good results of fractures reduction was protective factor.

TPF, the most common intra-articular fractures, was deemed as one of the most complex injuries in trauma surgery; appropriate treatment

Table 3. Comparison of characteristics of knee functional scores

	Excellent (n = 26)	Good (n = 18)	Average and poor (n = 15)	F/χ^2	P
Age	43.04 ± 8.26	44.50 ± 7.85	51.87 ± 10.68	5.02	0.01
Gender: male (n, %)	15 (57.7)	10 (55.6)	9 (60.0)	0.012	0.913
BMI	23.81 ± 4.35	24.94 ± 5.89	27.18 ± 4.13	2.219	0.12
History of knee OA (n, %)	3 (11.5)	3 (16.7)	5 (33.3)	2.778	0.096
Family history of OA (n, %)	3 (11.5)	1 (5.6)	3 (20.0)	0.418	0.518
Labor intensity (n, %)					0.326
Mental work	6 (23.1)	4 (22.2)	3 (20.0)	2.41	0.492
Stage I of labor intensity	13 (50.0)	10 (55.6)	8 (53.3)		
Stage II of labor intensity	7 (26.9)	4 (22.2)	3 (20.0)		
Stage III of labor intensity	0 (0.0)	0 (0.0)	1 (6.7)		
Smoking (n, %)	10 (38.5)	3 (16.7)	4 (26.7)	1.003	0.317
Drinking (n, %)	6 (23.1)	4 (22.2)	4 (50.0)	0.053	0.818
Fracture typing (n, %)				8.879	0.031
I~III types	7 (26.9)	4 (22.2)	0 (0.0)		
IV type	9 (34.6)	4 (22.2)	3 (20.0)		
V type	6 (23.1)	5 (27.8)	4 (26.7)		
VI type	4 (15.4)	5 (27.8)	8 (53.3)		
Associated injury around the knee (n, %)	13 (50.0)	3 (16.7)	6 (40.0)	0.922	0.337
Reset conditions after surgery (n, %)					
Average and poor	9 (34.6)	3 (16.7)	12 (80.0)	5.944	0.014
Excellent and good	17 (65.38)	15 (83.3)	3 (20.0)		
Time from injury to treatment (n, %)				6.334	0.012
≥14 d	21 (80.8)	16 (88.9)	6 (40.0)		
<14 d	5 (19.2)	2 (11.1)	9 (60.0)		
Traumatic knee OA (n, %)	6 (23.1)	3 (16.7)	11 (73.3)	8.73	0.003
Other postoperative complications (n, %)	8 (30.8)	7 (38.9)	3 (20.0)	0.327	0.567

BMI: body mass index; OA: osteoarthritis.

Table 4. Logistic regression analysis of factors influencing knee function

Influencing factors	B	SE	*P* value	OR	95% CI
Fracture typing					
IV type	0.75	0.86	0.383	2.11	0.39~11.30
V type	0.4	0.9	0.657	1.49	0.26~8.61
VI type	1.75	0.84	0.037	5.76	1.11~29.94
Associated injury around the knee	2.51	1.03	0.015	12.3	1.72~87.88
Reset conditions after surgery	-1.6	0.73	0.029	0.21	0.05~0.85
Traumatic knee OA	2.9	0.97	0.003	18.1	2.71~120.617

OA: osteoarthritis; B: partial regression coefficient; SE: standard error; OR: odd ratio; 95% CI: 95% confidence interval.

plays a crucial role in functional outcome [18]. Besides, TPFs were demonstrated correlated with important soft tissue or neurovascular injuries which can cause damage to the limbs in a certain extent [19]. Previous evidence proved that arthroscopic surgery can be one of the most efficiency procedures for the treatment of TPFs [20]. After multivariate analysis, we found that excellent-good results of fractures reduction was protective factor of traumatic knee OA after arthroscopic surgery treated TPFs and prognosis. The mechanism of which excellent-good results of fractures reduction was a protective factor can be concluded as follow: (1) arthroscopic surgery, as a minimally invasive surgery can bring little trauma for knee to conduct functional exercise at early stage and reduce the incidence of knee joint adhesion and stiffness; (2) that kind of procedure can search fracture morphology clearly for making corresponding treatment to minimize the incidence of disunion of fractures [21]. Previous study also clarified that probe can make collapse of articular surface a <2 mm anatomical reduction with an anatomical reduction rate of 93.5%~100% under arthroscopy, thus can reduce the occurrence of knee degeneration [22]. The features of fewer complications and shorter hospitalization time were also verified by previous study, suggesting that TPF patients received arthroscopic surgery can get better fractures reduction [23]. Consistent with our results, a perspective study conducted by *Rossi* et al. also revealed that TPF patients with fracture and intraarticular damage treated by internal fixation under arthroscopy achieved evident efficiency and safety [24].

As for the risk factors, our study also demonstrated that age, history of knee OA, and associated injury around the knee were independent risk factors of traumatic knee OA after arthroscopic surgery treated TPFs, and fracture typing, associated injury around the knee and traumatic knee OA were risk factors of knee function of prognosis. Due to physiological factors, elderly is prone to suffer from osteoporosis, so the external light can cause fractures [25]. Besides, as presented in the front content, TPF account for about 10% fractures in elderly [1], suggesting that age is a very important factor of traumatic knee OA after arthroscopic surgery treated TPFs. Data in other study also showed that traumatic knee OA and knee stiffness were two important factors causing poor efficacy in the long-term outcome of TPFs [26, 27]. Besides, studies conducted by *Horisberger* et al. and *Martin* et al. both revealed that the main causes of traumatic knee OA were incomplete articular surface and joint instability [28, 29]. And, the incidence of traumatic knee OA after a previous TPF approximately ranges from 22% to 44% [30], indicating that traumatic knee OA was an important risk factors of prognosis.

Taken together, our study provided evidence that independent risk factors of traumatic knee OA after arthroscopic surgery treated TPFs were age, history of knee OA, and associated injury around the knee, while, excellent-good results of fractures reduction was independent protective factor. Fracture typing, associated injury around the knee and traumatic knee OA were risk factors of prognosis, and excellent-good results of fractures reduction was protective factor. However, further studies with larger sample size and analysis on complications and typing should be conducted for further confirming our conclusion.

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Disclosure of conflict of interest

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