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Original Article

The arthroscopic minimally-invasive technique improves the clinical symptoms and facilitates the functional recovery of the lower limbs in knee joint bone trauma patients

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Abstract: Objective: This study aims to demonstrate the effect of the arthroscopic minimally invasive technique on the clinical symptoms and lower limb functional recovery in knee joint bone trauma patients. Methods: From January 2015 to January 2020, 150 knee joint bone trauma patients were recruited as the study cohort and divided into two groups according to the different intervention method each patient underwent. The patients in the control group (the CG, n=68) were administered routine treatment, and the patients in the research group (the RG, n=82) were treated using the arthroscopic minimally invasive technique. The postoperative clinical operative indexes and the clinical effectiveness, as well as the intraoperative complications were observed in the two groups. The inflammatory factor levels before and after the surgeries were compared. The Visual Analogue Scale (VAS) was employed to evaluate the pain levels before and after the surgeries, the Hospital for Special Surgery Knee Scores (HSS) were used to assess the knee joint recoveries before and at six months after the operations, and the Fugl-Meyer Assessment Scale (FMAS) was used to determine the lower limb functional recovery before and at six months after the operations. Results: The RG had significantly shorter operation times, lower intraoperative blood losses, shorter average ambulation times, shorter hospital stays, shorter fracture healing times, and smaller incisions than the CG. Postoperatively, the IL-8 and TNF-α levels were significantly lower in the RG than in the CG. The RG exhibited observably lower VAS scores after the operations, as well as evidently higher HSS scores and FMAS scores at six months postoperatively than the CG. In comparison with the CG, the RG had a significantly higher total effective rate and a noticeably lower incidence of postoperative complications. Conclusions: The arthroscopic minimally invasive technique is effective at treating patients with knee joint bone trauma, and it can promote the surgical recovery of patients and facilitate the functional recovery of the knee joint and the lower limbs.

Keywords: Knee joint bone trauma, arthroscopic minimally invasive technique, clinical symptoms, lower limb functional recovery

Introduction

The knee joint, an essential joint in the human body, has a complex physiological structure [1]. Bones are a highly specialized supporting framework characterized by rigidity, hardness, and the ability to regenerate and repair themselves [2]. With the development of the economy, people's occupation diversification and vehicle ownership rates are also increasing, which leads to an increasing incidence of knee joint bone trauma caused by traffic accidents, industrial operations, and improper exercise [3]. Mainly induced by external forces, knee joint bone trauma is relatively common in clinical practice, and in most cases, the patients are seriously injured, which may cause permanent trauma and affect patients' walking functions [4]. Therefore, it is paramount to choose the appropriate treatment methods to treat the condition.

At this stage, most patients with knee joint bone trauma undergo surgery [5]. While in the past, the majority were treated using open surgery, that is, the patient's fracture site was cut open to restore the fracture in situ [6]. However, as the medical literature indicates

[7], open surgery is too invasive, causes large secondary injuries, and can destroy the joint structure during surgery, leading to adverse patient prognosis. With encouraging results in the medical field in recent years, minimally invasive surgery has also been widely used in fracture reduction and other related diseases [8]. It is used mainly to reset and fix the fracture position and the patient's distal end with a steel plate, which will not affect the normal growth at the fracture position while effectively protecting the soft tissue at the patient's trauma site [9]. In addition, the small incision can greatly reduce the intraoperative blood loss and alleviate the adverse stimulation caused by the pain, thus facilitating the patients' postoperative recoveries [10]. The arthroscopic minimally invasive technique has been shown to be able to shorten operation times, which in turn reduces the contact between the fracture site and the outside air, thus lowering the incidence of postoperative complications such as infections [11]. For instance, the study by Defino et al. [12] revealed that percutaneous minimally invasive surgery for patients with thoracolumbar fractures can reduce the intraoperative bleeding, shorten the hospital stays, and mitigate patients' postoperative pain.

Herein, arthroscopic minimally invasive intervention was performed on patients with knee joint bone trauma to observe its effects on their clinical symptoms, pain levels, and inflammatory factor levels, as well as the functional recovery of their knee joints and lower limbs, aiming to provide better treatment and intervention schemes for the disease.

Materials and methods

General information

From January 2015 to January 2020, 150 patients with knee joint bone trauma who were treated with arthroscopic minimally invasive technique in People's Hospital of Baodi District were divided into two groups according to different intervention method each patient was administered. The patients in the control group (the CG, n=68) were administered routine treatment, and the patients in the research group (the RG, n=82) were treated using the arthroscopic minimally invasive technique. Inclusion criteria: All the patients met the diagnostic criteria for knee joint bone trauma [13], had complete clinical general data, had normal cognitive function and a correct understanding of the contents of the different scales used in this study. The hospital medical ethics committee approved this study without reservations, and the research participants and their families were informed and signed the full informed consent forms. Exclusion criteria: patients with familial hereditary diseases, immune system diseases or coagulation dysfunction, patients unable to undergo the treatment or the long-term follow-up, patients who were pregnant or lactating, patients with other systemic diseases, organic diseases, mental illnesses or neuropathy, patients unwilling to cooperate with the research, referred patients, and patients who quit the study halfway.

Surgical methods

The CG underwent routine surgical treatment: after debridement upon admission, a joint cavity puncture was performed using retrograde compression and repeated flushing according to the patient's condition to prevent a serious infection of the joint cavity caused by residual dirt at the wound site, and normal saline was required for the repeated flushing. Preoperatively, the patients were administered wide-spectrum antibiotics and given an intramuscular injection of 1500 IU tetanus antitoxin (Wuhan Institute of Biological Products Co., Ltd., Wuhan, China, S10820039), followed by epidural anesthesia. For those who couldn't apply internal fixation and whose bone edges were severely fractured, the bone fragments were cleared with forceps and perforated at the fracture edges, and then the joint capsule was closed with suture lines. Postoperatively, drainage, infection prevention, and swelling reduction were carried out depending on the actual situation, and appropriate rehabilitation training was carried out according to each patient's condition.

The patients in the RG were administered arthroscopic minimally invasive intervention: the preoperative and anesthetic methods were the same as those in the CG, as aforementioned. An endoscope was placed in the anterior part of the patient to ensure that the situation of the fractured limb bone was monitored in real time, and the other parts such as the meniscus, the cartilage, and the patient's cruci-

ate ligament were examined in detail. Also, attention was paid to observe whether the patient's affected limb was worn, etc., and any abnormality was immediately handled with targeted treatment once found. Finally, a reduction operation was performed on the patient's fracture site. Forceps were used to remove foreign bodies during the operation, and the wounds were cleaned promptly postoperatively. Drainage, infection prevention and swelling reduction were also performed after the operations according to the actual situation, and appropriate rehabilitation training was conducted according to each patient's condition.

Outcome measures

Clinical operative indexes: the operation durations, the sizes of the incisions, the intraoperative blood losses, the average time to ambulation, the hospitalization durations, and the fracture healing times were observed in both groups.

Inflammatory factors: 5 mL venous blood was drawn from the patients in both groups before and after the operation, centrifuged at 1500 r/min for 10 min, and stored in a freezer at -70°C for later use. The serum IL-8 and TNF-α levels were measured using ELISA [14], strictly following the kit instruction manual (Yiji Industrial Co., Ltd., Shanghai, China, BZE0087, YIJ100026).

Pain levels: The Visual Analogue Scale (VAS, highest possible score: 10 points) [15] was used to evaluate the patients' pain levels before and after the operations. The higher the score, the higher the pain level.

Follow-up: home visits were conducted at six months after the operations and scales were employed to evaluate the recovery of the patients' knee joint function and the lower limb function.

Knee joint function: the Hospital for Special Surgery Knee Scores (HSS) [16], covering 7 items with a total possible score of 100 points, were used to evaluate the patients' knee joints before and at six months after the operations. The higher the score after the evaluation, the better the knee joint function.

Lower limb function: The Fugl-Meyer Assessment Scale (FMAS) scores [17], with a total possible score of 100 points, were used to evaluate the recovery of the patients' lower limbs before and at six months after the surgeries. After the treatment, a score < 50 was classified as severe dyskinesia, 50-84 as significant dyskinesia, 85-95 as moderate dyskinesia, 96-99 as mild dyskinesia, and 100 as normal function. The higher the score, the higher the limb recovery.

Postoperative clinical effectiveness: the evaluation was divided into three dimensions: markedly effective, effective, and ineffective. Markedly effective was indicated if the patient presented with no pain in the knee joint, with a normal range of motion (ROM), and well recovered lower limb function after the surgery. The patients with occasional post-surgery knee joint pain, normal ROM, and good lower limb functional recovery after their surgery were rated as effective. If the patients had severe pain in the knee joint and a seriously reduced ROM, and they refused to get out of bed, they were regarded as ineffective. Total effective rate = (markedly effective + effective) cases/total cases × 100%.

The complications that occurred after the surgeries were observed and recorded.

Statistical methods

SPSS 22.0 (Beijing Easybio Co., Ltd., China) was used for the statistical analysis. Recorded as the number of cases/percentage [n (%)], the count data in the two groups were compared using Chi-square tests. Continuous correction Chi-square tests were used when the theoretical frequency in the Chi-square tests was less than 5. The measurement data were described as the mean ± standard deviation (mean ± SD) and were compared using independent sample T tests between the groups. Significance was determined when the probability (*P*) values were < 0.05.

Results

General information

The two groups showed no significant differences in terms of their general data such as

Table 1. Comparison of the clinical baseline data between the two groups [n (%)]/(mean ± SD)

Classification	Research group (n=82)	Control group (n=68)	t/χ^2	P
Gender			0.288	0.591
Male	47 (57.32)	36 (52.94)		
Female	35 (42.68)	32 (47.06)		
Average age (years old)	39.83±3.74	41.05±4.03	1.920	0.056
BMI (kg/m^2)	24.43±2.16	24.49±3.23	0.135	0.892
Mean injury duration (h)	8.38±0.31	8.43±0.33	0.955	0.341
Residence			0.563	0.453
Urban	42 (51.22)	39 (57.35)		
City	40 (48.78)	29 (42.65)		
Ethnicity			0.600	0.438
Han	45 (54.88)	33 (48.53)		
Ethnic minorities	37 (45.12)	35 (51.47)		
Educational background			0.996	0.318
≥ High school	49 (59.76)	46 (67.65)		
< High school	33 (40.24)	22 (32.35)		
History of smoking			0.268	0.604
Yes	46 (56.10)	41 (60.29)		
No	36 (43.90)	27 (39.71)		
Drinking history			0.613	0.433
Yes	43 (52.44)	40 (58.82)		
No	39 (47.56)	28 (41.18)		
Exercise history			0.161	0.687
Yes	48 (58.54)	42 (61.76)		
No	34 (41.46)	26 (38.24)		
Cause of injury			0.032	0.984
Traffic accident	29 (35.37)	25 (36.76)		
High fall injury	27 (32.93)	22 (32.35)		
Fall	26 (31.71)	21 (30.88)		
Fracture site			0.600	0.438
Left	37 (45.12)	35 (51.47)		
Right	45 (54.88)	33 (48.53)		

genders, average ages, body mass indexes (BMI), average injury times, residences, ethnicities, educational backgrounds, smoking histories, drinking histories, exercise histories, injury causes, and fracture sites (P > 0.05) (**Table 1**).

Comparison of the clinical operative indexes between the two groups

The RG had significantly shorter operation times, smaller intraoperative blood losses, shorter average ambulation times, shorter hospitalization times, faster fracture healing times, and smaller incisions than the CG (P < 0.05) (**Table 2**).

Comparison of the inflammatory factors between the two groups before and after the surgeries

The inflammatory factor IL-8 and TNF-α levels did not differ statistically between the CG and RG before the operations (P > 0.05), but the two levels increased notably after the operations (P < 0.05), and their levels were dramatically lower in the RG than they were in the CG at postoperative day seven (P < 0.05) (**Table 3**).

Comparison of the VAS scores between the two groups before and after the surgeries

The VAS scores were not statistically different between the two groups before the operations (P > 0.05), but the VAS scores declined dramatically in both the CG and the RG after the operations (P < 0.05), and the reduction was more profound in the RG (P < 0.05) (**Table 4**).

Comparison of the HSS scores between the two groups before and after the operations

The HSS scores had no significant differences between the two groups before the operations (P > 0.05), but at six months after the surgeries, the scores were increased observably in both groups, and the increase was more significant in the RG (P < 0.05) (**Figure 1**).

Comparison of the FMAS scores between the two groups before and after the operation

No evident differences were observed in the FMAS scores between the two groups before the operation (P > 0.05). After the surgeries, however, the FMAS scores increased significantly in both groups, and the increase was more evident in the RG (P < 0.05) (**Figure 2**).

Table 2. Comparison of clinical operative indexes between the two groups (mean ± SD)

Groups	n	Operation time (min)	Surgical incision (cm)	Intraoperative blood loss (mL)	Average ambulation time (min)	Hospitalization time (d)	Fracture healing time (weeks)
Research group	82	43.79±4.05	4.82±0.41	89.73±8.53	3.86±0.15	8.46±0.74	8.78±0.74
Control group	68	66.43±6.13	8.93±0.76	128.49±12.04	7.33±0.38	15.79±1.83	11.83±1.09
t	-	27.080	42.150	23.010	75.910	33.170	20.320
P	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Table 3. Comparison of the inflammatory factors between two the two groups before and after the surgeries (mean ± SD)

Groups	n	IL-8		TNF-α	
		Before operation	After operation	Before operation	After operation
Research group	82	9.68±0.94	11.53±1.27	10.47±1.85	12.74±1.93
Control group	68	9.57±0.91	13.79±1.51	10.62±1.88	16.54±1.87
t	-	0.723	9.957	0.490	12.170
P	-	0.470	< 0.001	0.624	< 0.001

Table 4. Comparison of the VAS scores between the two groups before and after the surgeries (mean ± SD)

Groups	n	VAS scores	
		Before operation	After operation
Research group	82	6.23±0.45	2.44±0.18
Control group	68	6.19±0.47	4.16±0.32
t	-	0.531	41.420
P	-	0.596	< 0.001

Comparison of the postoperative clinical effectiveness between the two groups

The total effective rate after the intervention was 93.90% in the RG and 77.94% in the CG. The comparison showed that after the surgeries, the RG had a higher total effective rate than the CG ($P < 0.05$) (**Table 5**).

Comparison of the postoperative complications between the two groups

The incidences of complications after the intervention were 3.66% in the RG and 17.65% in the CG. The comparison showed that the total incidence of postoperative complications in the RG was notably lower than it was in the CG ($P < 0.05$) (**Table 6**).

Discussion

Knee joint bone trauma is a condition seen commonly in clinics. The condition can lead to a dislocation of the knee joint and ligament strain, seriously affecting the patient's normal knee joint function [18]. In addition, the injured knee joint will have a big impact on patients' daily activities, even damaging their menisci in severe cases [19]. And the complex structure of the joint site makes the treatment trickier [20]. Therefore, effective intervention methods are particularly important to facilitate the recovery from knee joint bone trauma.

In this study, we used the arthroscopic minimally invasive technique to treat knee joint bone trauma patients and found that the patients' conditions were substantially ameliorated after their treatment. You et al. documented in their study that compared with traditional open surgery, minimally invasive surgical intervention for patients with acute displaced midclavicular fractures can significantly reduce their operation times and incision lengths, and can lower the incidence of postoperative complications [21]. Similar results were also obtained in this study, that is, we observed shorter operation times, smaller incisions, lower intraoperative blood losses, shorter average ambulation times, and shorter fracture healing times in the RG than in the CG. This demonstrates that with little harm to patients, the arthroscopic minimally invasive technique causes smaller incisions, which can reduce the intraoperative blood loss and facilitate the recovery of patients' wound sites, thus improving the patients' postoperative clinical indica-

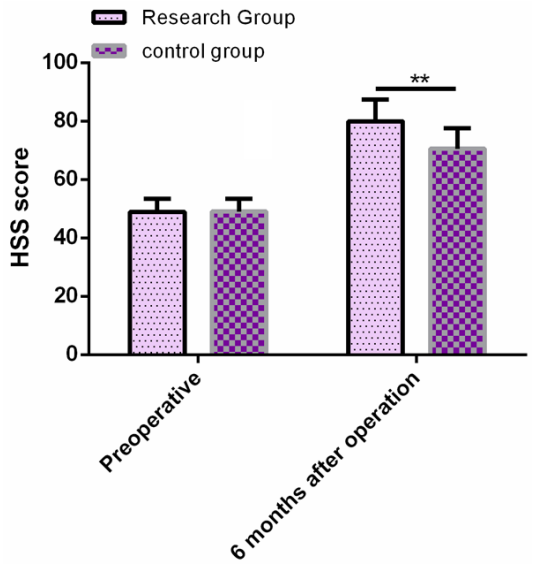

Figure 1. Comparison of the HSS scores between the two groups before and after the surgeries. There was no difference in the HSS scores between the two groups before the operations, but the HSS scores in the research group were significantly higher than the HSS scores in the control group at six months after the operations. Note: *indicates $P < 0.05$ vs. before the operations; **indicates $P < 0.01$ vs. the control group after the operations.

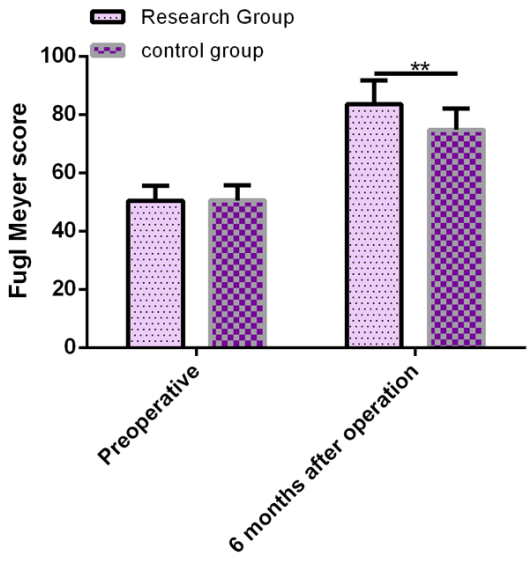

Figure 2. Comparison of the Fugl-Meyer Assessment Scale scores between the two groups before and after the operations. There was no difference in the Fugl-Meyer scores between the two groups before the operations, but the Fugl-Meyer scores in the research group were significantly higher than the corresponding scores in the control group at six months after the operations. Note: *indicates $P < 0.05$ *vs.* before operation; **indicates $P < 0.01$ *vs.* the control group after the operation.

tors. Surgical trauma can trigger changes in the levels of various factors in the patients, and the ones most closely related to the severity of the trauma are called trauma-related indexes. Take IL-8 as an example, when the patient is infected or suffering from autoimmune conditions, the IL-8 level will increase correspondingly [22]. Also, TNF-α possesses many immunomodulatory effects and is strongly associated with inflammatory reactions [23]. Our results indicate that the IL-8 and TNF-α levels in both groups increased significantly after the operations, which is similar to the findings of the above studies. The IL-8 and TNF-α levels in the RG were significantly lower than they were in the CG after the operations. This is because arthroscopic minimally invasive surgery requires only a small operating space and does not cause large area injuries, thus reducing the impact on the internal environment of the body and facilitating the control of postoperative inflammatory reactions. Severe postoperative pain is one that underlies the prolonged hospitalization and the high incidence of complications in most orthopedic patients [24]. In the study of Zhong et al. [25], patients with unstable distal radius fractures were treated using minimally invasive surgery and traditional surgery respectively. They found that the postoperative pain and arm-shoulder-hand disability scores of the patients with minimally invasive surgery were dramatically lower than they were in the patients with traditional surgery, while the postoperative wound aesthetic scores were statistically higher. This also agrees with the results of our study, that is, the VAS scores in the RG were significantly lower than the scores in the CG, suggesting that the arthroscopic minimally invasive technique has small incisions and a fast recovery of inflammation, which can relieve patients' postoperative pain to a great extent.

The arthroscopic minimally invasive technique can better clean up blood clots, cartilage fragments, and other residues, so as to repair soft tissue injuries and avoid problems like postoperative tissue adhesion [26]. Other studies have found that [27], minimally invasive surgical intervention for patients with refractory popliteal cysts can greatly reduce their postoperative pain, enhance the patients' ROM and ameliorate the flexion and extension functions of knee joint. Similarly, the HSS scores in the

Table 5. Comparison of the postoperative efficacy between the two groups [n (%)]

Groups	n	Markedly effective	Effective	Ineffective	Total effective rate (%)
Research group	82	45 (54.88)	32 (39.02)	5 (6.10)	77 (93.90)
Control group	68	24 (35.29)	29 (42.65)	15 (22.06)	53 (77.94)
χ^2	-	-	-	-	8.195
P	-	-	-	-	0.004

Table 6. Comparison of the postoperative complications between the two groups [n (%)]

Groups	n	Synarthrophysis	Infection	Lower limb thrombosis	Osteofascial compartment syndrome	Total incidence (%)
Research group	82	1 (1.22)	2 (2.44)	0 (0.00)	0 (0.00)	3 (3.66)
Control group	68	3 (4.41)	4 (5.88)	3 (4.41)	2 (2.94)	12 (17.65)
χ^2	-	1.459	1.148	3.61	2.444	8.082
P	-	0.227	0.284	0.054	0.117	0.004

RG were found to be noticeably higher than the HSS scores in the CG at six months after the operations, indicating that the arthroscopic minimally invasive technique can effectively carry out reduction and internal fixation, and accelerate the recovery of joint function, thus improving patients' knee joint function of patients. Also, the FMAS scores were significantly higher in the RG at six months after the operations, demonstrating that the arthroscopic minimally invasive technique did little harm to the wound surface of patients and reduced the postoperative recovery times, thereby speeding up the lower limb functional recovery of the patients. Further, the efficacy comparison revealed that the total effective rate was statistically higher in the RG. It shows that with less trauma to patients, the arthroscopic minimally invasive technique can shorten operation times and accelerate the postoperative recovery from trauma, thereby improving the postoperative clinical effectiveness. Postoperative complications that cause any deviation from the normal postoperative process, and controlling postoperative complications remain a major clinical challenge [28]. Our research showed that the total incidence of postoperative complications in the RG was evidently lower than it was in the CG, which is also similar to the study of Chiang et al. [29]. They found that minimally invasive surgery in ankle fracture patients can effectively alleviate the postoperative pain, reduce the incidence of complications, and the incidence of reoperation. Also, it shows that the arthroscopic minimally invasive technique has the merits of reducing postoperative related infections, thus reducing postoperative complications.

Although this study shows that the arthroscopic minimally invasive technique can provide more benefits for patients with knee joint bone trauma, there is still room for improvement. For example, we can include a larger cohort and measure additional factors, and analyze the factors affecting the arthroscopic minimally invasive technique to support this study, which will help the medical staff to identify the risk factors that require additional attention. In the future, supplementary studies from the above perspectives will be carried out gradually.

To sum up, the arthroscopic minimally invasive technique has a significant effect on patients with knee joint bone trauma, and it can speed up the surgical recovery of patients and improve the functional recovery of the knees and the lower limbs.

Disclosure of conflict of interest

None.

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