Chinese Journal of Traumatology 24 (2021) 169–173

Contents lists available at ScienceDirect

Chinese Journal of Traumatology

journal homepage: http://www.elsevier.com/locate/CJTEE

Original Article

Comparison of the clinical efficacy of different fixation systems for the treatment of transverse patellar fractures

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ARTICLE INFO

Article history:
Received 21 December 2020
Received in revised form
10 January 2021
Accepted 11 February 2021
Available online 26 February 2021

Keywords:
Transverse patellar fractures
"0" fixation system
Double-head cannulated compression screw

ABSTRACT

Purpose: This study was designed to compare the clinical efficacy of "8" and "0" wire fixation systems combined with double-head cannulated compression screws or Kirschner wires for the treatment of transverse patellar fractures.

Methods: From September 2011 to September 2018, patients with closed transverse patellar fractures treated with a double-head compression screw or Kirschner wire were included and analyzed retrospectively. Patients with patellar fractures combined with distal femoral fractures, tibial plateau fracture or preoperative lower limb dysfunction were excluded. The patients treated with the "8" tension band wire fixation system and Kirschner wire were taken as Group A; those treated with the "0" fixation system and Kirschner wire were taken as Group B; those treated with the "8" fixation system and double-head cannulated compression screw were taken as group C; and those treated with the "0" fixation system and double-head cannulated compression screw were taken as group D. Six weeks and one year after the operation and every month from the third month after the operation until the fractures healed, an X-ray examination was performed to identify fracture healing. The time of fracture healing and postoperative complications of the four groups were compared. One year after the operation, knee function was evaluated by Bostman's score.

Results: During the study period, 168 patients with patellar fractures were treated by operations, and 88 patients were excluded because the fracture type did not meet the requirements or because there were combined fractures of the distal femur or tibial plateau. As a result, 80 patients were included in this study, 20 in each group. All the patients were followed up for an average period of 12.2 months. Compared with Group A, patients in Group D presented less postoperative discomfort in the prepatellar region, quicker fracture healing, less fixation failure and better postoperative knee function scores (all $p < 0.05$). The incidence of internal fixation failure in Group (B+D) was lower than that in Group (A+C) ($p > 0.05$).

Conclusion: The "0" wire fixation system combined with a double-head cannulated compression screw seems to be more beneficial than the other three fixation systems for the treatment of transverse patellar fractures.

Introduction

As intra-articular fractures, patellar fractures are associated with an increased risk of knee arthroplasty and knee arthroscopy, and may lead to more severe consequences than previously considered.[1] Comminuted patellar fractures accompanied by a complete knee extension apparatus can be treated by non-operative treatment, but when the knee extension apparatus is impaired, the step distance of the joint surface is more than 2 mm or the separating displacement is more than 4 mm, the fracture should be treated by operation.[2]

The current methods for treating patellar fractures are mainly as follows: wire cerclage, tension band wire fixation and cannulated lag screws. Combined with tension band wire fixation systems, Kirschner wire and cannulated lag screws are widely used for the treatment of patellar fractures. Kirschner wire combined with an

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Peer review under responsibility of Chinese Medical Association.

https://doi.org/10.1016/j.cjtee.2021.02.009

"8" tension band wire fixation system is the gold standard treatment strategy for patellar fractures. The mechanism of tension band wire fixation is to turn the tension of the front surface of the patella into the pressure on the joint surface to promote the healing of the fracture. When combined with Kirschner wire, "8" tension band can resist the contraction force of the quadriceps femoris while maintaining the reduction of the fracture, but it cannot be performed by a minimally invasive method and may be associated with a relatively high incidence of postoperative complications, such as Kirschner wire loosening, internal fixation failure and local soft tissue irritation.[3] For complex patellar fractures, the clinical efficacy of the Kirschner wire "8" fixation system is not satisfactory, and wire cerclage ("0" fixation system) or screw fixation is also usually needed. In addition, combined with the tension band wire fixation system for the treatment of patellar fractures, cannulated lag screws have the effect of dynamic compression on the fracture fragments, but the tail of the cannulated lag screw is difficult to fully embed into the patella, which may induce stress concentration and fixation failure. In a multivariable regression analysis, cannulated screws were associated with a 1.3 times greater risk of failure than Kirschner wires.[4]

When combined with Kirschner wire or cannulated screws for the treatment of patellar fractures, there are several methods for setting wire fixation systems, among which the "8" wire fixation system is widely used. However, after comparing the biomechanical characteristics of different fixation systems by finite element analysis, it was found that the "0" fixation system was more stable than the "8" fixation system, but this needs to be verified by clinical studies.[5]

It was hypothesized in this study that a double-head compression screw (Qwix screw), which can be fully embedded into the patella and combined with a "0" wire fixation system, could improve the knee joint function and reduce the incidence of postoperative complications in the treatment of transverse patellar fractures. This study was conducted to compare the clinical efficiency of these two kinds of fixation systems combined with Kirschner wire or Qwix screw in the treatment of transverse patellar fractures.

Methods

Selection of patients

This research was approved by the Ethics Committee of the First Affiliated Hospital of Chongqing Medical University. From September 2011 to September 2018, patients with closed transverse patellar fractures treated with a double-head compression screw or Kirschner wire were included and analyzed retrospectively. Inclusion criteria: (1) patients with closed transverse patellar fractures were treated with an operation; (2) according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification, the fracture types were 34-C1 or 34-C2; (3) the fracture fragment was able to hold the Qwix screw with a diameter of 4.3 mm; (4) the range of flexion and extension of the patients' bilateral knee joints before the injury was normal; (5) patients were treated with a "8" or "0" wire fixation. The exclusion criteria were as follows: (1) patients with fractures of the distal femoral fracture or tibial plateau; (2) patients who had difficulty communicating and cooperating with the treatment after the operation; and (3) patients with other diseases that might lead to joint dysfunction of the lower extremities. Group A, "8" fixation system and Kirschner wire group; Group B, "0" fixation system and Kirschner wire group; Group C, "8" fixation system and double-head cannulated compression screw group; Group D, "0" fixation system and double-head cannulated compression screw group. X-ray examination, CT and 3D reconstruction of the fracture sites were performed to identify the fracture types.

Surgical procedure

An anterior median incision of the patella was used to expose the superior and inferior poles of the patella and the extensor retinaculum, remove any blood stasis and rinse the joint cavity. One side of the joint capsule was cut longitudinally, and the fracture fragments were accurately restored by touching the articular surfaces of the patella. The fracture fragments were fixed with Kirschner wire or guiding needles. After the patellar articular surface was flattened, Qwix screws of the corresponding length were drilled along the guide needle, and the "8" or "0" wire fixation system was fixed with the steel wire through the cannulated part of the screw. The diameters of the steel wire and Qwix screw were 1.0 mm and 4.3 mm, respectively. Qwix screw parameters: the diameter of the thread area was 5.5 mm, the length was 4.0 mm, the pitch was 1.0 mm; the diameter of the front thread was 4.3 mm, the length was 8–26 mm (screw length: thread length = 1:0.3), the pitch was 1.25 mm; the diameter of the screw was 2.8 mm; the diameter of the cannulated part of the screw was 1.6 mm. Then, C-arm fluoroscopy was used to examine the fracture fixation. Passive flexion and extension of the knee joint was performed to check its range of motion. A negative pressure drainage tube was placed in the wound, and the incision was closed layer by layer.

Postoperative management

On the first day after the operation, isometric contraction of the quadriceps femoris and passive flexion and extension of the knee joint were performed by continuous passive motion. Active flexion and extension exercises of the knee joint were advised on the third day after the operation. The drainage tube was usually pulled out within 72 h after the operation. One week after the operation, full weight-bearing and walking with bilateral armpit sticks were allowed. Six weeks after the operation, the bilateral axillary sticks were removed, and daily activities gradually resumed. Within the first three months after the operation, intense physical activity was not allowed until the fracture healed.

Follow-up

X-ray examination was performed six weeks after the operation, and a monthly X-ray examination was performed three months after the operation until fracture healing to guide functional exercise. According to the plain film and condition of the patient, it was determined how to exercise step by step. One year after the surgery, the knee function was evaluated by Bostman's score,[6] and fracture healing was evaluated by X-ray examination.

Statistical analysis

IBM SPSS Statistics 21.0 was used for statistical analysis, and the data are expressed as the mean ± standard deviation. The measurement data were analyzed by the rank sum test, and the count data were analyzed by the Chi-square test. A p value < 0.05 was defined as significant.

Results

During the study period, 168 patients with patellar fractures were treated with operations, and 88 patients were excluded because the fracture type did not meet the requirements or it was combined with fractures of the distal femur or tibial plateau. The

Table 1
General information of the patients ($n = 20$ for each group).

Groups	Age (years)	Sex	Fracture type (AO classification)
		Male/Fmale	34-C1/34-C2
A	49.2 ± 7.1	11/9	12/8
B	50.7 ± 7.3	12/8	13/7
C	47.1 ± 6.2	11/9	11/9
D	51.2 ± 7.6	12/8	12/8
$p_{A\text{-}B}$	0.541	1.0	1.0
$p_{C\text{-}D}$	0.095	1.0	1.0
$p_{AB\text{-}CD}$	0.439	1.0	0.82
$p_{A\text{-}C}$	0.385	1.0	1.0
$p_{A\text{-}D}$	0.400	1.0	1.0
$p_{B\text{-}D}$	0.797	1.0	1.0

$p_{A\text{-}B}$: difference between groups A and B; $p_{C\text{-}D}$: difference between groups C and D; $p_{AB\text{-}CD}$: difference between groups A, B and C, D; $p_{A\text{-}C}$: difference between groups A and C; $p_{A\text{-}D}$: difference between groups A and D; and $p_{B\text{-}D}$: difference between groups B and D.

general information of the patients is listed in Table 1. Each group contained 20 cases of closed transverse patellar fractures, treated with an "8" or "0" wire fixation system combined with Kirschner wire or double-head cannulated compression screws. All the patients were followed up with an average follow-up period of 12.2 months. All fractures of each group healed clinically, and no loss of reduction was observed. There was no significant difference in the ratio of males to females, age distribution or fracture type distribution among the different groups. The X-ray images of the patellar fractures treated with the four different fixation systems are shown in Fig. 1.

Compared to the "8" fixation system, the average fracture healing time, functional scores and the occurrence of international fixation failure and discomfort in the prepatellar region of the "0" fixation group were all improved, but the difference was not significant.

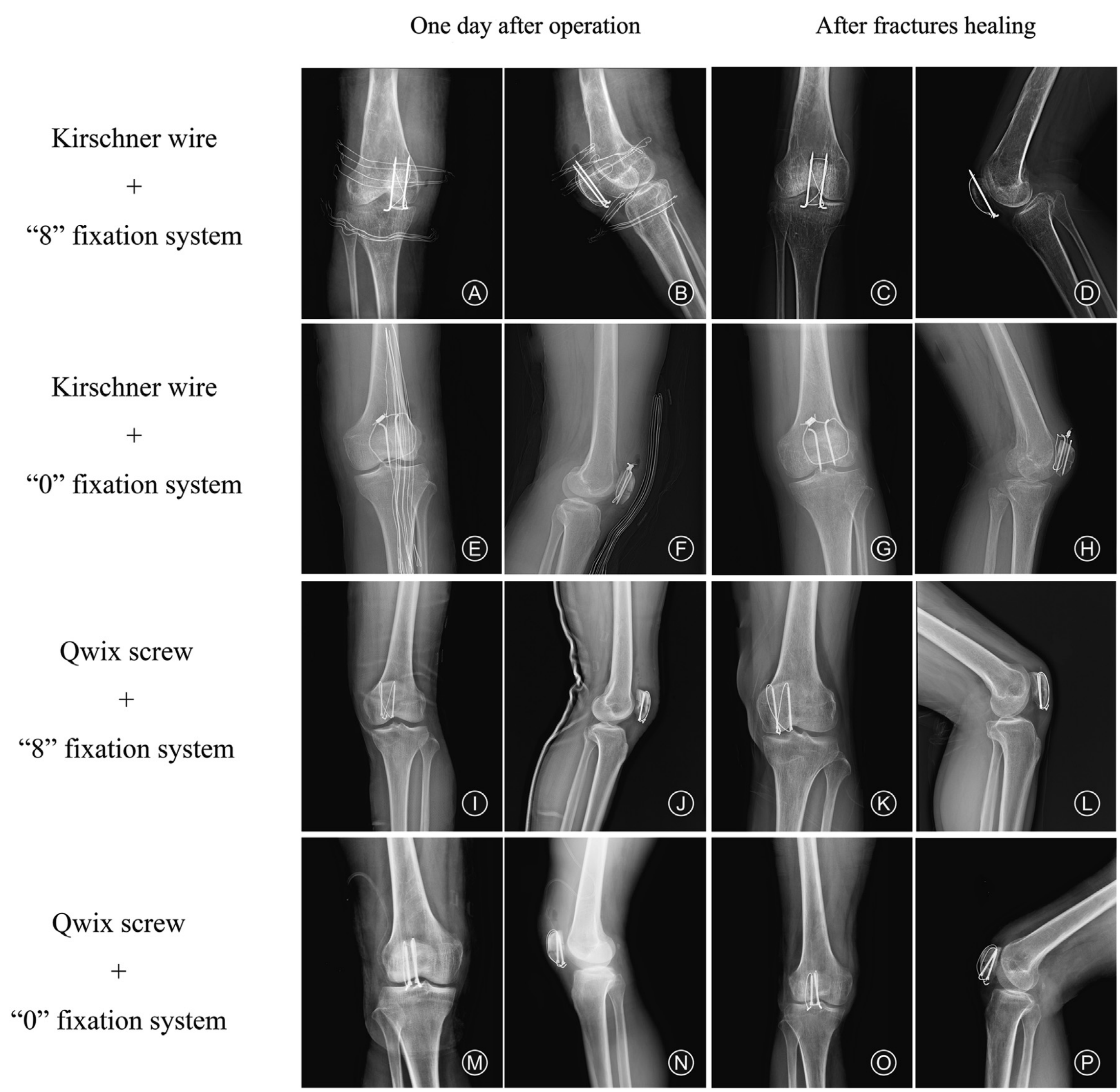

Fig. 1. X-ray images of transverse patellar fractures fixed by four different fixation systems. (A, B, E, F, I, J, M and N) X-ray images obtained one day after the operation; (C, D, G, H, K, L, O, and P) X-ray images obtained when the fractures healed. A, B, C, D and E, F, G, H represent the transverse patellar fractures fixed by Kirschner wire combined with "8" or "0" wire fixation systems; I, J, K, L and M, N, O, P represent the transverse patellar fractures fixed by double-head cannulated compression screws combined with "8" or "0" wire fixation systems.

Table 2
The follow-up results of the patients in the different groups.

Groups	Follow-up (months)	Fracture healing (months)	Internal fixation failure (n)	Discomfort in the prepatellar region (n)	Function scores
A	12.5 ± 1.4	4.3 ± 0.8	6	7	24.8 ± 2.5
B	12.2 ± 0.5	4.1 ± 0.8	3	6	25.2 ± 2.9
C	12.1 ± 0.3	3.0 ± 0.9	2	2	27.8 ± 1.0
D	12.2 ± 0.5	2.9 ± 0.7	0	0	28.6 ± 1.8
$p_{A\text{-}B}$	0.931	0.295	0.451	1.0	0.843
$p_{C\text{-}D}$	0.959	0.744	0.487	0.487	0.068
$p_{AB\text{-}CD}$	0.466	0.000	0.048	0.003	0.000
$p_{A\text{-}C}$	0.572	0.000	0.235	0.127	0.000
$p_{A\text{-}D}$	0.604	0.000	0.020	0.008	0.000
$p_{B\text{-}D}$	0.655	0.000	0.231	0.020	0.000

$p_{A\text{-}B}$: difference between groups A and B; $p_{C\text{-}D}$: difference between groups C and D; $p_{AB\text{-}CD}$: difference between groups A, B and C, D; $p_{A\text{-}C}$: difference between groups A and C; $p_{A\text{-}D}$: difference between groups A and D; and $p_{B\text{-}D}$: difference between groups B and D.

According to Bostman's score, the average functional scores of the cannulated compression screw groups were higher than those of the Kirschner wire group, and the average fracture healing time, incidence of internal fixation failure and discomfort in the prepatellar region were also significantly improved. Compared with the classic "8" fixation system combined with Kirschner wire for the treatment of patellar fractures, both the "8" and "0" fixation systems combined with cannulated compression screws could significantly improve the fracture healing time and function scores, but only the latter could significantly reduce the incidence of internal fixation failure ($p = 0.02$) and discomfort in the prepatellar region ($p = 0.008$) (Table 2).

In the Kirschner wire "8" fixation system group, one patient developed pain and infection of the incision in the prepatellar area four weeks after the operation. The X-ray examination showed that the steel wire was displaced, but there was no obvious loss of reduction. The patient was treated with debridement and the Kirschner wire "8" fixation system again. The fracture healed five months after the second operation and the patient ended up with limited knee flexion one year later. Among patients (13/40) with prepatellar discomfort after receiving treatment with Kirschner wire, displacement of internal fixation was observed in five patients, of whom two were accompanied by deep venous thrombosis treated with rivaroxaban. Wire fracture without obvious discomfort or limitation of knee joint movement was observed in two patients in the Kirschner wire combined with the "8" or "0" fixation system groups one year after the operation. In the cannulated screw group, two patients developed discomfort in the prepatellar area four months after the operation. The discomfort of the knee joint was significantly relieved in patients (15/80) after the internal fixation was removed.

Discussion

Compared with the classic Kirschner wire combined with the "8" fixation system, the Qwix screw combined with the "0" fixation system showed a better clinical effect in the treatment of transverse patellar fractures. During the operation, different setting methods, such as the "8" and "0" fixation systems, have different biomechanical properties. It was found that compared to the Kirschner wire "8" fixation system, "0" instead of the "8" fixation system combined with the Qwix screw could significantly reduce the incidence of internal fixation failure and discomfort in the prepatellar region for the treatment of transverse patellar fractures, which was consistent with a finite element analysis showing that the "0" fixation system was more stable than the "8" fixation system for the treatment of transverse patellar fractures.[5] In the current study, the "8" fixation system might be twice as likely to fail as the "0" fixation system when combined with the Kirschner wire or Qwix screw, which was likely clinically significant even in the absence of statistical significance. The difference might have reached significance if more patients were available for the study.

Qwix screws and double-head cannulated compression screws were more beneficial than Kirschner wires for patients with transverse patellar fractures. At present, the efficacy of cannulated compression screws and Kirschner wires combined with tension band wires in the treatment of patellar fractures is still controversial. It has been reported that compared with Kirschner wire, cannulated compression screws could significantly improve the postoperative knee function of patients with patellar fractures.[7,8] Wu et al.[9] also found that the maximum load-bearing capacity of cannulated compression screws and tension band wires was 732 N, while that of the Kirschner wire tension band was only 395 N during the treatment of patellar fractures. However, it was also reported that there was no significant difference in postoperative knee function, fracture healing time or fixation failure between patients treated with these two fixation methods.[10] Additionally, from a retrospective study, it was observed that cannulated screws may be twice as likely to fail as Kirschner wire, which may cause more soft-tissue irritation and wound-healing problems.[4]

In previously published reports, cannulated compression screws with unilateral threads were mostly studied, and the tail portion was usually difficult to completely embed in the patella, which might lead to stress concentration and wire fracture in this part.[11] In this study, Qwix screws with both head and tail threads were used and they significantly improved the functional scores of the knee joint and reduced the incidence of postoperative complications when combined with the "0" fixation system for the treatment of transverse patellar fractures. The reasons may be as follows: first, the Qwix screw is more easily fully embedded into the patella, which effectively avoids the stress concentration in the tail portion like a cannulated lag screw; second, with the thread in the tail portion and a larger diameter than a cannulated lag screw, the Qwix screw has continuous static compression[12] and more pullout strength[13] on the fracture fragments. Two patients treated with cannulated compression screws also developed discomfort in front of the knee joint after the operation. It was thought that the tail of the Qwix screw failed to be fully embedded in the patella during the operation.

In summary, four internal fixation systems for the treatment of transverse patellar fractures were compared and analyzed in this study, and it was found that the "0" fixation system combined with a Qwix screw was beneficial to shorten the fracture healing time, improve the postoperative knee function scores and reduce the occurrence of postoperative complications. There were also some shortcomings in this study. For example, it was a retrospective study, the sample size was limited, and the follow-up time was relatively short. Therefore, there might be some deviation in the conclusion, and randomized controlled trials with larger sample sizes are needed to further confirm this conclusion.

Funding

Nil.

Ethical statement

This study was approved by the ethics committee of the First Affiliated Hospital of Chongqing Medical University. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Declaration of competing interest

All authors declare no conflicts of interest.

Acknowledgments

We sincerely appreciate the outpatient visits discussed in our manuscript. Thank you for the contribution that you have made to the cause of human medicine. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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