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Original Article

A comparative study of open reduction with internal fixation and percutaneous poking reduction fixation for the treatment of Sanders type II calcaneal fractures

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Abstract: Objective: To compare and analyze the clinical efficacy of open reduction with internal fixation and percutaneous poking reduction fixation for Sanders type II calcaneal fractures. Methods: A total of 57 patients with calcaneal fractures were randomly divided into the poking group (27 cases, underwent percutaneous poking reduction) and the incision group (30 cases, underwent open reduction with internal fixation). The operation time, drainage volume, intraoperative blood loss, and hospitalization days were recorded. During the postoperative follow-up, fracture healing and incidence of complications were observed and recorded for both groups. At the last follow-up, Visual Analog Scale (VAS), American Orthopaedic Foot and Ankle Society (AOFAS) score, and the MOS item short form health survey (SF-36) were used to evaluate the clinical efficacy. Results: The operation time, drainage volume, intraoperative blood loss and hospitalization days in poking group were significantly less than those in the incision group, with statistically significant differences ($P<0.05$). In the postoperative follow-up, it was found that there was no significant difference in fracture healing time between the two groups. The incidence of complications was 3.70% in poking group, significantly lower than 10.00% in incision group ($P<0.05$). The Böhler and Gissane angles were significantly improved after surgery in both groups ($P<0.05$), but there was no significant difference between the two groups after surgery ($P>0.05$). At the last follow-up, VAS and SF-36 scores in the poking group were significantly higher than those in the incision group ($P<0.05$). There was no significant difference in excellent and good rate between the poking group and the incision group ($P>0.05$). Conclusion: Percutaneous poking reduction fixation can effectively reduce the incidence of postoperative complications and significantly improve the clinical efficacy and outcomes in treatment of Sanders II calcaneal fractures, so it is an efficient treatment method for calcaneal fractures.

Keywords: Calcaneal fractures, percutaneous poking reduction fixation, open reduction with internal fixation

Introduction

Calcaneal fracture is a common trauma in Department of Orthopedics, mostly caused by traffic accident, falling injury and so on [1]. At present, surgical treatment is mainly used clinically, including open reduction with internal fixation (ORIF) and percutaneous poking reduction fixation, etc [2]. Open reduction with internal fixation (ORIF) is a traditional surgical treatment for calcaneal fractures, with advantages of simple operation and adequate exposure, which can effectively reset the fracture site and offer secured fixation [3]. However, ORIF also has some limitations such as large surgical trauma and many postoperative complications [4]. Therefore, the selection of optimal treatment method is still a hot spot in the study of calcaneal fractures. In the 1950s, British surgeon Essex-Lopresti Peter first developed the percutaneous poking reduction fixation for the treatment of calcaneal fractures [5]. This method has the advantages of smaller trauma, low incidence of complications and fast postoperative recovery [6]. So it has been widely used since it was invented. However, percutaneous poking reduction technology requires more stringent indications and highly technical requirements [7]. At present, the clinical studies on the treatment of Sanders type II calca-

neal fractures by percutaneous poking reduction fixation have not been massively reported both in domestic and abroad. The objective of this study was to compare and analyze the clinical efficacy of open reduction with internal fixation and percutaneous poking reduction fixation for the treatment of Sanders type II calcaneal fractures.

Materials and methods

General information

57 patients with Sanders type II calcaneal fractures in Department of Orthopedics in our hospital from February 2013 to December 2014 were selected in this study. These 57 patients were randomly divided into the poking group and incision group. In the poking group, there were 27 patients, including 14 males and 13 females, aged from 22 to 65 years old, with an average age of 41.77±4.17 years old; 15 cases had fractures in the left, and 12 cases in the right; body mass index (BMI): 21-31.5 kg/m^2, with an average value of 24 kg/m^2; the cause of injury: traffic injury in 12 cases, falling injury in 15 cases; Böhler angle (14.4±4.5)°, Gissane angle (87.1±5.7)°; the average time from injury to surgery was (12.8±2.8) d. In the incision group, there were 30 patients, including 15 males and 15 females, aged from 20 to 67 years, with an average age of 42.57±5.57 years; 17 cases had fractures in the left and 13 cases in the right; body mass index (BMI): 20.5-32 kg/m^2, with an average value of 23.8 kg/m^2; cause of injury: traffic injury in 20 cases, and falling injury in 10 cases; Böhler angle (15.1±3.4)°, Gissane angle (88.2±5.5)°; the average time from injury to surgery was (11.8±2.7) d. There were no significant differences in gender, age, body mass index, lateral, fracture side, Böhler angles, Gissane angles, the time from injury to surgery and other general information between two groups (P>0.05), so these two groups were comparable.

Treatment method

The patients in poking group received the surgery treatment of percutaneous poking reduction fixation: after the satisfaction of patients with subarachnoid block anesthesia, patients took the normal lateral position, with conventional disinfection and draping. One Kirschner wire was drilled on the edge of achilles tendon. If the X-ray results confirmed that the Kirschner wire had reached the bottom of posterior articular calcaneal, upward poking was performed to reset the posterior articular surface and the calcaneal at the same time. When necessary, two Kirschner wires could be drilled in for fixation. Upon satisfaction with the reduction in imaging examination, the wound was washed and plaster fixation was performed.

The patients in incision group received open reduction with internal fixation: its preoperative preparation was the same as the poking group. Then incision ("L" shaped) was made at about 5cm above the lateral calcaneal of lateral supramalleolar. After separating soft tissues, traction was performed in the nodules and the calcaneal was reset after poking the collapsed calcaneal. Suitable steel plate was used for internal fixation after the reduction. As the imaging results showed satisfied reduction and fixing effects, conventional negative pressure drainage was performed, incision was sutured, and plaster fixation was implemented.

Postoperative management

Antibiotics were postoperatively used in a routine manner, combined with ice compress, pressure dressing, and raising the affected limb for treatment. Negative pressure drainage was removed at 48 h postoperative, with ankle joint activities from postoperative day 2, and the stitches were taken out three weeks after the operation. In the regular follow-up in outpatient clinic, the occurrence of complications was recorded, Böhler angles and Gissane angles of the patients were measured, and radiography was performed to evaluate the healing of fractures. In the last follow-up, the ankle joint scoring systems of Visual Analogue Scale (VAS), the Short Form-36 Health Survey (SF-36), and Maryland Foot Score standard by American Orthopaedic Foot and Ankle Society (AOFAS) were used to evaluate the final clinical efficacy.

Statistical treatment

All the data were statistically analyzed by SPSS 17.0 software. Measurement data were expressed with $\overline{X}\pm S$, and t test was used for comparison between groups; the enumeration data were expressed with percentage, and χ^2 test was used for comparison between groups.

Table 1. Comparison of operation-related indexes and hospitalization duration between two groups

Group	Case	Operation time (min)	Drainage volume (ml)	Intraoperative blood loss (ml)	Hospitalization duration
Poking group	27	19.4±7.2	15.4±1.1	17.8±6.5	5.6±1.5
Incision group	30	71.5±10.1*	21.1±1.2*	66.5±16.4*	18.1±5.2*
P value		0.015	0.034	0.034	0.024

**P*<0.05, compare with poking group.

Table 2. Comparison of postoperative complications between two groups

Group	Case	Pinhole infection	Incision infection	Fibula impingement syndrome	Total incidence rate (%)
Poking group	27	1	0	0	3.70
Incision group	30	0	2	1	10.0*
P value		0.013	0.034	0.034	0.014

**P*<0.05, compare with poking group.

Table 3. Comparison of the Böhler angles and Gissane angles between two groups

Group	Case	Böhler angles		Gissane angles	
		Preoperative (°)	Postoperative (°)	Preoperative (°)	Postoperative (°)
Poking group	27	14.4±4.5	26.6°±4.7*	87.1°±5.7	135.7°±9.1*
Incision group	30	15.1±3.4	25.1°±3.5*	88.2°±5.5	136.6°±11.5*
P value		0.078	0.032	0.013	0.012

**P*<0.05, compare with preoperative value.

Table 4. Comparison of AOFAS and VAS scores between two groups

Group	Case	AOFAS	VAS	SF-36
Poking group	27	92.2±7.3	2.5±0.1	81.5±8.1
Incision group	30	91.8±6.7	1.1±0.2*	64.2±6.5*
P value		0.153	0.0124	0.0147

**P*<0.05, compare with poking group.

There was statistically significant difference when P<0.05.

Results

Comparison of operation time, intraoperative blood loss and hospitalization days between two groups

The operation time was 11~27 min (mean value of 19.4±7.2 min) in the poking group and 62~115 min (mean value of 71.5±10.1 min) in the incision group, with significant difference between the two groups (*P*<0.05). The drainage volume was 12~21 ml (mean value of 15.4±1.1 ml) in the poking group, lower than 18~25 ml (mean value of 21.1±1.2 ml) in the incision group, with statistically significant difference (*P*<0.05). The mean intraoperative blood loss was 66.5±16.4 ml in the incision group, and 17.8±6.5 ml in the poking group, with significant difference between the two groups. The mean hospitalization duration was (5.6±1.5) d in the poking group, and (18.1±5.2) d in the incision group, with statistically significant difference between the two groups. See **Table 1** for details.

Comparison of postoperative complications between two groups

After treatment with these two different surgical methods, the internal fixator had no loosening or cracking in both groups. In the 27 patients of poking group, pinhole infection was present in only 1 patient, with an incidence rate of 3.70%; while in the 30 patients of incision group, incision infection was present in 2 patients, and fibula impingement syndrome was observed in 1 patient, with an incidence rate of 10.00%. The incidence of complications in the incision group was significantly higher than that in the poking group, with statistically significant difference between the two groups (*P*<0.05). See **Table 2** for details.

Comparison of Böhler angles and Gissane angles between two groups of patients with calcaneal fractures

The preoperative Böhler angles were (14.4±4.5)° and (15.1±3.4)° respectively in the poking group and incision group; and the postop-

Table 5. Maryland Foot Score

Items of Maryland Foot Score	Score
Pain	45
Painless	45
Slight pain	40
Mild pain	30
Moderate pain	20
Marked pain	10
Severe pain	0
Function	55
Gait	
(1) Walking distance	
Unlimited	10
Slight limitation	8
Moderate limitation	5
Severe limitation	2
Only indoor activities	0
(2) Stability	
Normal	4
Feel bad but without losing stability	3
Occasional instability	2
Frequent instability	1
Need to use orthotic device	0
(3) Auxiliary support	
None	4
Walking stick	3
Cane	1
(4) limp	
None	4
Slight	3
Moderate	2
Severe	1
Can not walk	0
Functional activities	
(1) Type of shoes	10
(2) Climb up stairs	4
(3) Walking terrain	4
(4) Joint activity	5
Appearance	
(1) Normal	10
(2) Mild deformity	8
(3) Moderate deformity	5
(4) Severe deformity	0
Total	100

Note: the patients with total score of 90-100 points are graded as "excellent", 75-89 points as "good", 50-75 points as "available", and those under 50 points are graded as "poor".

erative Böhler angles were (28.6±4.7)° and (28.1±3.5)° respectively. Both groups were significantly improved as compared with preoperative Böhler angles (P<0.05); but there was no significant difference between two groups after operation (P>0.05). The preoperative Gissane angles were (87.1±5.7)° and (88.2±5.5)° respectively in of the poking group and incision group; and the postoperative Gissane angles were (135.7±9.1)° and (136.6±11.5)° respectively. It was also significantly improved in both groups as compared with preoperative conditions, with statistically significant difference (P<0.05); but there was no statistically significant difference between two groups after operation (P>0.05). See **Table 3** for details.

Comparison of AOFAS, VAS and SF-36 scores between two groups

The patients were followed up for 22-49 months in the poking group (with a mean value of 36.2±12.1 months) and 23-48 months in the incision group (with a mean value of 36.7±12.3 months). There was no significant difference in the fracture healing time between the poking group (4.9±0.7 months) and incision group (5.1±0.8 months) (P>0.05). The postoperative AOFAS, VAS and SF-36 scores were 92.2±7.3, 2.5±0.1, and 81.5±8.1 respectively in the poking group, and 91.8±6.7, 1.1±0.2, and 64.2±6.5 in the incision group. VAS and SF-36 scores in the poking group were significantly higher than those in the incision group, with statistically significant difference (P<0.05), but there was no significant difference in AOFAS scores between the two groups. See **Table 4** for details.

Comparison of postoperative Maryland Foot Scores between two groups

In the 27 patients of poking group, 12 patients achieved "excellent", and 9 patients achieved "good", with an excellent and good rate of 77.8%. In the 30 patients of incision group, 15 patients achieved "excellent", and 10 patients achieved "good", with an excellent and good rate of 83.3%. There was no statistically significant difference in excellent and good rate between these two groups (P>0.05). See **Tables 5** and **6** for details.

Discussion

Calcaneal fracture is a common trauma in Department of Orthopedics, mostly caused by traffic accident, falling injury and so on.

Table 6. Comparison of Maryland Foot Score between two groups

Group	Case	Excellent rate (%)	Good rate (%)	Excellent and good (%)	Available or poor (%)
Poking group	27	12 (44.4%)	9 (33.3%)	77.8%	6 (22.2%)
Incision group	30	15 (50%)	10 (33.3%)	83.3%	5 (16.7%*)
P value		0.235	0.213	0.145	0.1346

Calcaneal is a very important bearing bone of the human body, so it is very easy to affect the daily life and work of patients in case of improper treatment for calcanea fractures. At present, surgical treatment is mainly used clinically, including open reduction with internal fixation (ORIF) and percutaneous poking reduction fixation, etc. Open reduction with internal fixation (ORIF) is a traditional surgical treatment for calcaneal fractures, with advantages of restoring the anatomic calcaneal morphology and talocalcaneal joints matching, which could achieve good clinical effect and reduce the incidence of traumatic arthritis. However, incision complications with varying degrees of severity are often found after ORIF, even chronic calcaneal osteomyelitis may be present [8, 9]. The results of this study showed that the incidence of complications in patients undergoing ORIF in the incision group was up to 10%. The complications such as incision infections and pain would seriously affect the prognosis and long-term clinical efficacy for patients.

To make up for these limitations and disadvantages, some scholars recommended percutaneous poking reduction fixation for the treatment of calcaneal fracture. It was to pry up the collapsed articular surface by using the lever principle, combined with manual reduction of the calcaneal height and articular surface [10]. Studies showed that open reduction with internal fixation and percutaneous poking reduction fixation can obtain satisfactory therapeutic effect [11]. Moreover, percutaneous poking reduction fixation has low incidence of postoperative complications, less trauma, fast recovery of postoperative functions and other advantages that are nonexistent in other methods [12]. In this study, the operation time was (19.4±7.2) min in the poking group, significantly shorter than (71.5±10.1) min in the incision group; the drainage volume was (15.4±1.1) ml in the poking group, significantly lower than (21.1±1.2) ml in the incision group; the intraoperative blood loss was (17.8±6.5) ml in the poking group, significantly lower than (66.5±16.4) ml in the incision group; the hospitalization duration was (5.6±1.5) d in the poking group, significantly shorter than (18.1±5.2) d in the incision group. The comparisons in all the above indices have a *P* value less than 0.05 that stands for statistically significant differences between two groups.

In addition, the incidence of complications was 3.70% in the poking group, significantly lower than 10% in the incision group, with significant differences ($P<0.05$). The postoperative Böhler angles and the Gissane angles were significantly improved in both groups ($P<0.05$), but there was no significant difference between two groups after operation ($P>0.05$). This showed that the percutaneous poking reduction fixation was equally effective with the conventional ORIF in the correction of Böhler angles and Gissane angles. Besides, at the last follow-up, AOFAS, VAS, SF-36, and Maryland Foot Scores in two groups were measured and recorded. VAS and SF-36 scores in the poking group were significantly higher than those in the incision group, with statistically significant difference ($P<0.05$). This indicated that the patients undergoing percutaneous poking reduction fixation could have better long-term curative effect and higher quality of life. The results of Maryland Foot Score system showed that the excellent and good rate was 77.8% in the poking group and 83.3% in the incision group, with no statistically significant difference ($P>0.05$). This indicated that both percutaneous poking reduction fixation and conventional ORIF have very high excellent and good rate as well as satisfactory clinical efficacy.

Poking reduction fixation has many advantages in the treatment of calcaneal fractures, but there are also some defects [13, 14]. Previous studies showed that poking reduction fixation can often achieve more satisfactory efficacy for the fractures where the articular surface destruction and displacement are not very serious, such as Sanders type I fractures [15]. However, with the continuous increase of Sanders type, the patients would have correspondingly increased proportion of postoperative pain and dysfunction [16]. Analysis showed

that it may be because the poking reduction was difficult to achieve complete anatomical reduction for the fractures where the articular surface is seriously destroyed and displaced [17]. In addition, the minimally invasive poking reduction is difficult to completely remove the small pieces of broken bones in the articular cavity, resulting in the uneven surface of subtalar joint and leading to traumatic arthritis [18]. It also seriously affects the long-term efficacy and prognosis. The clinical efficacy of poking reduction fixation for Sanders type II fractures was studied for the first time in this trial, and it was comprehensively analyzed and compared with the traditional ORIF method. X-ray was used to make sure that after the Kirschner wire had reached the bottom of posterior articular calcaneal, upward poking could be conducted to reset the posterior articular surface and calcaneal at the same time, and 2 Kirschner wires can be drilled in when necessary. The incision was sutured after satisfactory with the reduction results in imaging examination, ensuring the complete reduction of the articular surface, long-term efficacy and prognosis [19, 20]. This type of research has not been widely reported both at home and abroad.

In summary, poking reduction fixation for Sanders type II calcaneal fractures can achieve the same excellent and good rate with traditional ORIF, obtain satisfactory efficacy, effectively shorten the operation time, reduce intraoperative blood loss and postoperative drainage volume, shorten the hospitalization duration, reduce the incidence of postoperative complications, and improve functional recovery, prognosis and quality of life, which is worthy of popularization in clinical application.

Declaration of conflict of interest

None

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References

[1] Schepers T. The sinus tarsi approach in displaced intra-articular calcaneal fractures: a systematic review. Int Orthop 2011; 35: 697-703.

[2] DeWall M, Henderson CE, McKinley TO, Phelps T, Dolan L and Marsh JL. Percutaneous reduction and fixation of displaced intra-articular calcaneus fractures. J Orthop Trauma 2010; 24: 466-472.

[3] Rammelt S, Amlang M, Barthel S, Gavlik JM and Zwipp H. Percutaneous treatment of less severe intraarticular calcaneal fractures. Clin Orthop Relat Res 2010; 468: 983-990.

[4] Woon CY, Chong KW, Yeo W, Eng-Meng Yeo N and Wong MK. Subtalar arthroscopy and flurosocopy in percutaneous fixation of intra-articular calcaneal fractures: the best of both worlds. J Trauma 2011; 71: 917-925.

[5] Mostafa MF, El-Adl G, Hassanin EY and Abdellatif MS. Surgical treatment of displaced intra-articular calcaneal fracture using a single small lateral approach. Strategies Trauma Limb Reconstr 2010; 5: 87-95.

[6] Femino JE, Vaseenon T, Levin DA and Yian EH. Modification of the sinus tarsi approach for open reduction and plate fixation of intra-articular calcaneus fractures: the limits of proximal extension based upon the vascular anatomy of the lateral calcaneal artery. Iowa Orthop J 2010; 30: 161-167.

[7] Besch L, Waldschmidt JS, Daniels-Wredenhagen M, Varoga D, Mueller M, Hilgert RE, Mathiak G, Oestern S, Lippross S and Seekamp A. The treatment of intra-articular calcaneus fractures with severe soft tissue damage with a hinged external fixator or internal stabilization: long-term results. J Foot Ankle Surg 2010; 49: 8-15.

[8] Kissel CG, Husain ZS, Cottom JM, Scott RT and Vest J. Early clinical and radiographic outcomes after treatment of displaced intra-articular calcaneal fractures using delta-frame external fixator construct. J Foot Ankle Surg 2011; 50: 135-140.

[9] Mehta S, Mirza AJ, Dunbar RP, Barei DP and Benirschke SK. A staged treatment plan for the management of Type II and Type IIIA open calcaneus fractures. J Orthop Trauma 2010; 24: 142-147.

[10] Goldzak M, Mittlmeier T and Simon P. Locked nailing for the treatment of displaced articular fractures of the calcaneus: description of a new procedure with calcanail(®). Eur J Orthop Surg Traumatol 2012; 22: 345-349.

[11] Jacquot F and Atchabahian A. Balloon reduction and cement fixation in intra-articular calcaneal fractures: a percutaneous approach to intra-articular calcaneal fractures. Int Orthop 2011; 35: 1007-1014.

[12] Tomesen T, Biert J and Frolke JP. Treatment of displaced intra-articular calcaneal fractures with closed reduction and percutaneous screw fixation. J Bone Joint Surg Am 2011; 93: 920-928.

[13] Dayton P, Feilmeier M and Hensley NL. Technique for minimally invasive reduction of calcaneal fractures using small bilateral external fixation. J Foot Ankle Surg 2014; 53: 376-382.
[14] Illert T, Rammelt S, Drewes T, Grass R and Zwipp H. Stability of locking and non-locking plates in an osteoporotic calcaneal fracture model. Foot Ankle Int 2011; 32: 307-313.
[15] Hammond AW and Crist BD. Percutaneous treatment of high-risk patients with intra-articular calcaneus fractures: a case series. Injury 2013; 44: 1483-1485.
[16] Schepers T. The primary arthrodesis for severely comminuted intra-articular fractures of the calcaneus: a systematic review. Foot Ankle Surg 2012; 18: 84-88.
[17] Pelliccioni AA, Bittar CK and Zabeu JL. Surgical treatment of intraarticular calcaneous fractures of sanders' types II and III. Systematic review. Acta Ortop Bras 2012; 20: 39-42.
[18] Gurkan V, Dursun M, Orhun H, Sari F, Bulbul M and Aydogan M. Long-term results of conservative treatment of Sanders type 4 fractures of the calcaneum: a series of 64 cases. J Bone Joint Surg Br 2011; 93: 975-979.
[19] Badillo K, Pacheco JA, Padua SO, Gomez AA, Colon E and Vidal JA. Multidetector CT evaluation of calcaneal fractures. Radiographics 2011; 31: 81-92.
[20] Schepers T, van Lieshout EM, Ginai AZ, Mulder PG, Heetveld MJ and Patka P. Calcaneal fracture classification: a comparative study. J Foot Ankle Surg 2009; 48: 156-162.