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Mid-Term Efficacy of Surgical Treatment for Calcaneal Fracture Combined with Die-Punch Bone Block

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Abstract: To discuss the surgical efficacy and experience of calcaneal fracture combined with die-punch bone block. Open reduction and internal fixation for 27 patients (27 feet) with calcaneal fracture combined with die-punch bone block were performed, the die-punch bone blocks were untreated in earlier stage, calcaneal anatomical recovery and function were evaluated during follow-up in one year after surgery. The follow-up results for the 27 patients in one year after the surgeries show the postoperative width of intraoperative die-punch bone block treatment group was significantly better than that of non-treatment group (p<0.05), the postoperative functional scores of treatment group were superior to those of non-treatment group (p<0.05), and there were no significant differences in preoperative and postoperative calcaneal height, length, Bohler angle and Gissane angle between treatment group and non-treatment group (p>0.05). According to 100-point criteria of Tieliang Zhang, there were 1 excellent case, 2 good cases, 4 medium cases and 2 poor cases in non-treatment group, and there were 5 excellent cases, 10 good cases, 2 medium cases and 1 poor case in treatment group; the scores of the treatment group were better than those of the untreated group (p<0.05). For intra-articular calcaneal fractures combined with die-punch bone block, it is necessary to pay attention to the surgical anatomical reduction. The steps of articular surface should be controlled within 1mm. The treatment for calcaneal fracture combined with die-punch bone block must be performed by open reduction and internal fixation, and meanwhile the treatment for die-punch bone block should be emphasized, in order to reduce the occurrence of dysfunction during recovery.

Keywords: Intra-Articular Calcaneal Fracture, Die-Punch Bone Blocks, Internal Fixation

1. Introduction

The treatment methods for intra-articular calcaneal fractures caused by high-energy violence are different, so the postoperative treatment effects are also uncertain. The treatment for articular surface fractures has become a consensus. Even so, many patients are dissatisfied with the recovery of joint function in postoperative mid-term. This may be because calcaneal morphology and articular surface recovery are emphasized but the treatment for the cartilage or subchondral bone (die-punch bone block) collapsed in the cancellous bone is ignored in surgical treatment for the fracture. For this purpose, a mid-term follow-up study for the 27 patients who suffered from calcaneal fracture combined with die-punch bone block and received treatment in our hospital from January 2010 to June 2013 was performed in 1 year after surgery. The results of the follow-up study are now reported as follows.

2. Methods

2.1. General Information

The data for the 27 patients (27 feet) who suffered from calcaneal fracture combined with die-punch bone block, received and cured in our hospital from January 2010 to June 2013 were collected, in which there were 22 males and 5 females, aged 29-55 years old, with an average age of 34.5 years old. The cause of their injuries was a fall from a high

place. According to Sanders classification[1], there were 0 Type I foot, 6 Type II feet, 17 Type III feet and 4 Type IV feet. In the earlier stage, there were 9 patients (9 feet) who were not treated seriously and whose die-punch bone blocks were not treated; in the later period, the die-punch bone blocks for the remained 18 patients (18 feet) were treated.

2.2. Treatment Methods

2.2.1. Preoperation Preparation

X-ray films of bilateral lateral calcanei were taken routinely before surgery, CT scan and three-dimensional reconstruction for the affected calcanei were performed, and the height, width, length, Bohler angle and Gissane angle for preoperative affected calcanei were measured and analyzed, in order to make displacement fracture and collapse of the involved articular surface clear and definite. After emergent admission to hospital, cold compress was applied in 48 hours, swelling and pain relief treatment was performed; operations were performed after wrinkles of local skin appeared in 1 week or so.

2.2.2. Operation Method

Bleeding was bundled up and stopped with conventional rubber blood driven belt. An "L" shaped incision was expanded outside of the heel to reveal protective sural cutaneous nerve. The whole soft tissue outside the calcaneous together with the periosteum were lifted, three Kirschner wires were inserted into the distal tibia, the talus and the cuboid, and incision flap was pulled and opened to fully expose the fracture end and the subtalar joint. The fracture block was restored by traction, poking, squeezing, pinching and other methods; the treatment for die-punch bone block depended on poking reduction of the articular cartilage and the subchondral bone collapsed in the cancellous bone under the articular surface; a window was opened outside of the calcaneus, Kirschner wires or fine periosteal stripper was used to reduce the pressure to achieve anatomic reduction; according to the bone defect, bone grafting was performed appropriately. Three-point fixation for the calcaneus steel plate was made in order to achieve effective and reliable overall fixation. By X-ray fluoroscopy, the rest fixation was confirmed, the field of view was flushed, it was layered vertically, the incision was sutured, 1 silicone drainage tube was placed in the incision, the heel was incised additionally and connected with drainage bag, and elastic bandage was used for pressure bandaging.

2.2.3. Postoperative Treatment

The affected limbs were raised continuously after surgery, and the toes were moved actively and passively. The drainage tube was removed in 48 hours after surgery, and exercises for the ankle joint were started. The dressing was changed in time to keep the incision dry. In general, the suture was removed in 3 weeks after surgery, X-ray examination was performed in 12 weeks in order to determine the fracture healing, and then gradually walking with load.

2.3. Evaluation of Curative Effect

The patient's calcaneal anatomical parameters were quantitatively measured and functionally scored in 1 year after surgery. Anatomical parameters included calcaneal height, width, length, Bohler angle and Gissane angle in 1 year before surgery and after surgery. 100-point criteria from Tielaing Zhang et al was adopted: 86-100 points (excellent), 71-85 points (good), 51-70 points (medium) and 0-50 points (poor) [2].

2.4. Statistical Analysis

The measured data of normal distribution is expressed by $\bar{x} \pm s$. *T* test was used in two sets of numerical data for group design. Rank sum test was used in two sets of graded data for group design. Results were processed by SPSS 13.0 software, and $p<0.05$ was considered to be statistically significant.

3. Results

All the 27 patients were followed up in one year after surgery. The recovery of postoperative calcaneal width in treatment group was better than that in non-treatment group ($p<0.05$, Table 1). There were no significant statistical differences in the preoperative and postoperative calcaneal height, length, Bohler angle and Gissane angle between treatment group and non-treatment group ($p>0.05$, Table 1). According to 100-point criteria of Tieliang Zhang, there were 1 excellent case, 2 good cases, 4 medium cases and 2 poor cases in non-treatment group, and there were 5 excellent cases, 10 good cases, 2 medium cases and 1 poor case in treatment group; the scores of the treatment group were better than those of the untreated group ($p<0.05$, Table 2, Figure 1). The superficial skins of the incisions of 2 feet became black and necrotic, and healed after dressing treatment, without deep infection; in 3 feet, traumatic arthritis occurred in 7-9 months after surgery, pain and discomfort in the ankle occurred after 500 meters of continuous walking, and relieved after a break.

Table 1. *Comparison of anatomical parameters in 1 year before and after the surgery for calcaneal fractures combined with die-punch bone block.*

	Case(n)	height(mm)		width(mm)	
		Preoperative	Postoperative	Preoperative	Postoperative
non-treatment group	9	32.94±0.83	40.63±0.80	35.40±1.35	33.75±1.46
treatment group	18	32.93±1.39	40.54±1.29	36.08±1.35	31.28±1.66
P value		0.977	0.851	0.225	0.00086

Table 1. *Continue.*

	length(mm)		Bohler angle(°)		Gissane angle(°)	
	Preoperative	**Postoperative**	**Preoperative**	**Postoperative**	**Preoperative**	**Postoperative**
non-treatment group	66.09±1.86	71.16±2.27	10.29±1.39	28.88±2.43	87.21±1.95	114.62±3.44
treatment group	65.65±2.32	70.60±1.93	11.38±1.50	30.41±1.64	89.57±3.69	117.76±4.16
P value	0.624	0.507	0.079	0.063	0.086	0.062

Table 2. *Comparison of functional scores between treatment group and non-treatment group in 1 year after surgery.*

	Operation mode		total
	Untreated group	**treated group**	
excellent	1	5	6
good	2	10	12
mediate	4	2	6
bad	2	1	3
total	n1=9	n2=18	27

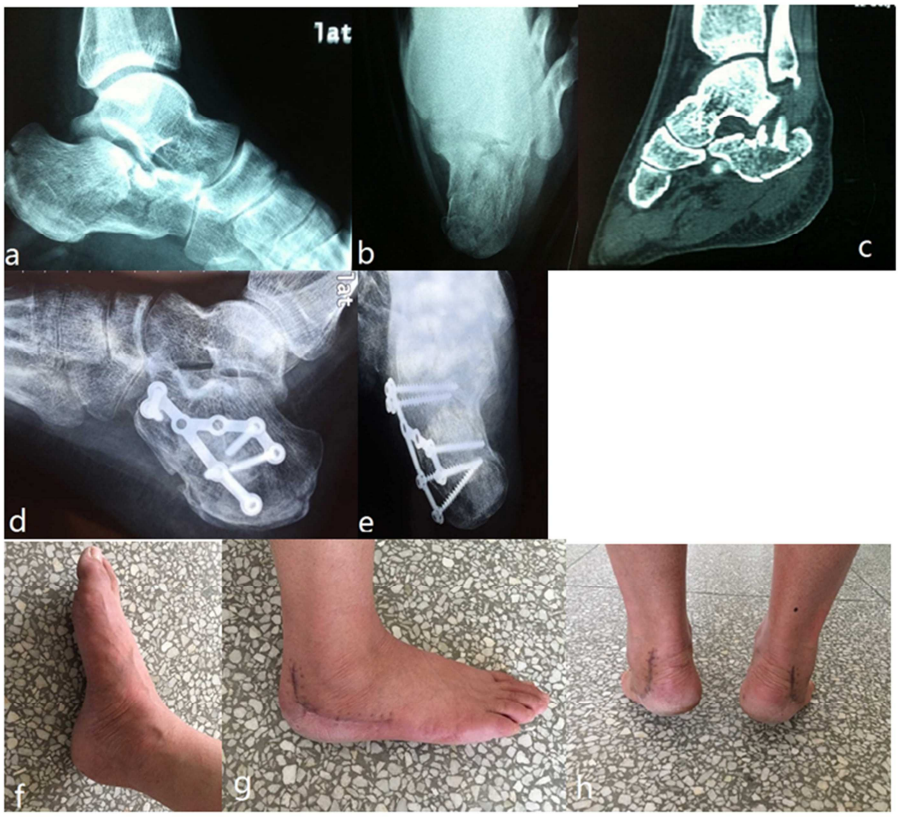

Figure 1. *Male patient, 41 years old, anatomical reduction of right intra-articular calcaneal fracture combined with die-punch bone block.*

a and b are X-ray side axial images, c is the calcaneal sagittal CT image, which shows articular surface collapse combined with die-punch bone block. d and e are X-ray side axial images during follow-up in 1 year after surgery; f, g and h are inversion and ectropion activity and heel-off appearance for right foot during follow-up in one year after surgery.

4. Discussion

Calcaneal fractures are the most common tarsal fractures, about 75% of which are intra-articular fractures. Surgical treatment is the main strategy for intra-articular fractures, which can both restore the shape of fracture part and achieve the reconstruction of articular surface. Damaged articular cartilage increases the difficulty of fracture reduction and reconstruction[3]. If there is no effective treatment available, it can cause traumatic arthritis and even dysfunction in the future. Therefore, the treatment for intra-articular calcaneal fractures requires both the restoration of bone block shape in fracture area and complete reconstruction of articular surface.

Die-punch bone block means that some of the articular cartilage and subchondral bone are embedded in the cancellous bone at the time of intra-articular fracture. Die-punch bone block can be found at the time of intra-articular fractures such as the fractures of acetabulum, tibial plateau, calcaneus, distal radius and pilon fracture[4-5]. In many domestic literatures, there are many studies on distal radius fracture combined with die-punch bone block, but there are few studies on intra-articular calcaneal fracture combined

with die-punch bone block. A retrospective study on intra-articular calcaneal fractures combined with die-punch bone block was mainly carried out in this paper.

Most of the clinical calcaneal fractures have complexities, mechanical parameters of bone block change obviously, and biomechanical changes change seriously. For posterior calcaneal articular surface fracture combined with die-punch bone block, it is often overlooked clinically, and it is not easy to find by routine X-ray examination. But it can be found by coronal and axial CT scan. In the past, for surgical treatment of calcaneal comminuted fractures, the restoration of overall calcaneal shape and length, width, height and other geometric parameters are emphasized, and the restoration of the Gissane angle, Bohler angle and the weight-bearing axis of hind feet are emphasized. Open reduction and internal fixation for involved subtalar articulatio calcaneocuboidea injury and calcaneal fracture were performed by Zongjun Li et al, and the restoration of Gissane angle and Bohler angle were emphasized, for which the total good rate was 95.2% after surgery[6]. During regular follow-up after surgery, the above anatomical parameters basically returned to normal, and the patients were very satisfied with this; however, in the long-term, these patients often still have joint pain and even dysfunction. However, through further CT scans, it was found that some of partial subchondral bone for the patients with dysfunction were collapsed in the posterior articular surface of calcaneal subtalar joint and the cancellous bone of the corpus calcanei; this change was not found in the patients with normal function through CT scans. In the patients with anatomical reduction for the die-punch bone block, if the recovery of Bohler angle is not very good, their mid-term and long-term pain is not obvious, and their joint function is also barrier-free. We also found that the calcaneal width was significantly reduced on the die-punch bone after anatomical reduction, which might be related to the expanding of the collapsed bone block and fracture separation. This phenomenon is particularly evident in comminuted fractures.

A large number of studies show that the evenness of posterior calcaneal articular surface is very important and its clinical efficacy is closely related to the degree of reduction [7-8]. By regular observations from Sanders et al, it is found that the postoperative long-term effect depends on the reduction degree of calcaneal articular surface, that is to say, CT examination shows postoperative persistent chronic pain and traumatic arthritis complications may occur even if there is slight unevenness on the articular surface [9]. Gavlik et al also found that the patients with broken subtalar articular surface step>1mm were worse than those with a flat (even) articular surface in joint function, while there would be significant difference between the patients only when the difference was above 40% in the recovery of the Bohler angle [10]. The unsuitable chief complaints of the postoperative patients were mainly related to the unevenness of the subtalar joints, rather than the poor recovery of the Bohler angle. This is consistent with our findings, that is, the recovery of joint function is still good even if the restoration of calcaneal anatomical landmark is not good enough. Biomechanical studies have also shown that even a slight 1-2 mm unevenness on articular surface will cause significant changes in the weight-bearing characteristics of subtalar joints [7]. Therefore, the reduction of posterior articular surface fractures has become the focus of surgical treatment of calcaneal fractures. Experimental study from domestic Zhenhu Wang et al shows that surgical reduction should be performed when metatarsal side displacement of posterior articular surface fracture of calcaneal subtalar joint is ≥2mm [11]. Recently, Rammelt et al advocated that the step of articular surface for the fracture >1mm should be operated [12]. The author believes that, for intra-articular calcaneal fractures combined with die-punch bone block, it is necessary to pay attention to the surgical anatomical reduction, that is to say, “float”or “flip” the cartilage and subchondral bone collapsed in the cancellous bone for restoration (or reduction). The steps of articular surface should be controlled within 1mm, and meanwhile autogenous bone or allogeneic bone should be used for adequate bone grafting to maintain the restoration in accordance with specific conditions. In future clinical work, we should pay attention to the diagnosis and treatment of intra-articular calcaneal die-punch bone blocks to reduce the occurrence of long-term weight-bearing walking dysfunction.

5. Conclusion

In this study, we found that, the recovery of postoperative calcaneal width in die-punch bone block treatment group was better than that in non-treatment group. The postoperative functional scores of the treatment group were superior to those of the untreated group. Both difference was statistically significant. We recommend that the treatment for calcaneal fracture combined with die-punch bone block must be performed by open reduction and internal fixation, and the treatment for die-punch bone block should be emphasized.

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