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*Original Article*

# Comparative study on treatment of sanders type III calcaneal fractures with/without bone grafting

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**Abstract:** Objective: To Compare the clinical efficacy of treatment of sanders type III calcaneal fractures by bone grating and by open reduction combined with internal fixation (ORIF) and to investigate the effects of bone grafting for sanders type III calcaneal fractures. Methods: 60 patients with sanders type III calcaneal fractures who were treated in our hospital from January 2013 to December 2015 were selected in this study, and divided into the bone graft group (30 cases) and the non-bone graft group (30 cases), each group having 30 feet (30 feet). The non-bone graft group underwent open reduction and internal fixation while the bone graft group was treated with bone grafting combined with ORIF. After the postoperative follow-ups, both groups' calcaneal reduction and imaging examination results were compared in the four aspects of Bolher's angle, Gissane's angle, calcaneal width and fracture healing time; and the postoperative recovery of foot function was also compared between the two groups according to the Maryland foot scores; Visual Analog Scale (VAS) and the Short Form 36 Health survey Questionnaire (SF-36) were compared between two groups; and the SPSS 19.0 software was applied for statistical analyses. Results: The two groups were followed up, with an average time of 26 months. The bone graft group did not start full weight-bearing walking until week 8 after operation, while the non-bone graft group did not do start until week 12. And there were no significant differences in fracture healing time and incision healing between the two groups ($P>0.05$) while the operation time of the bone graft group was significantly longer than that of the non-bone graft group, and the difference was statistically significant ($P<0.05$). Besides, there were no significant differences in the postoperative recovery of calcaneal width, Gissane's angles and Bolher's angles between the two groups ($P>0.05$). There were no significant differences in Maryland foot scores of 6 months, 1 year and 2 years after operation between the two groups ($P>0.05$). There were no significant differences in VAS score and SF-36 scores for 2 years after operation between two groups ($P>0.05$). The postoperative 1-year and 2-years SF-36 scores in the bone graft group were significantly higher than those of the non-bone graft group, and the difference was statistically significant ($P<0.05$). Conclusions: Bone grafting cannot significantly improve the postoperative functional recovery of the patients with sanders type III calcaneal fracture when it combined with open reduction and internal fixation, but it actually plays a role in the improvement of the life quality and earlier functional exercise for patients.

**Keywords:** Calcaneal fractures, sanders type III, bone graft, internal fixation, therapeutic efficacy

## Introduction

Calcaneal fractures are one of the most common lesions in orthopaedics, mainly caused by fall from a height or traffic accidents. Displaced intra-articular fracture is still a challenge for the treatment of orthopedics. Open reduction and internal fixation (ORIF) is the first-line treatment for sanders type III calcaneal fractures. A study reported that the compression of cancellous bone in the calcaneal fractures often results in loss of local bone mass and reduction of the articular surface tends to be followed by some bone defects [1, 2]. Currently, the goals of the therapies for sanders type III calcaneal fractures are the same as those of common calcaneal fracture therapies, that is, maximizing the restoration of the normal anatomic alignment of calcaneus maintaining the stability of the reduction of calcaneus and reducing the postoperative complications to restore the normal functions of calcaneus [3]. However, the effects of using bone grafting to fill the space created after reduction of sanders type III calcaneal fractures remains unclear [4]. Studies have shown that bone grafting can remedy the bone defects, prevent the form and progress of hematoma, and reduce the incidence of infection [5, 6]; another report showed that bone grafting would be considered only when bone defect is too large or fracture fragment is extremely unstable after reduction [7, 8]. Therefore, from January 2013 to December 2015, 60 patients with sanders type III calcaneal fractures who were treated with open reduction and internal fixation (ORIF) combined with bone grafting in our hospital were included in our study. Of them, 30 cases underwent ORIF combined with bone grafting and 30 cases only underwent ORIF. In this study, we compared the clinical efficacy of the two groups of patients and investigated the efficacy of bone grafting for the treatment of sanders type III calcaneal fractures.

## Materials and methods

### *General information*

The subjects were selected from the patients with sanders type III calcaneal fractures who were treated in our hospital from January 2013 to December 2015. After the patients with complications including other tarsal bone fractures like merged talus, navicular bone, any compound injury, pathological fracture or any medical diseases such as coronary heart disease and diabetes had been excluded, 60 cases in compliance with our criteria were included in our study and divided into two groups: the ORIF group (the bone graft group) and the ORIF combined with bone graft group (the non-bone graft group). Among them, 30 cases (30 feet) were in the bone graft group, including 16 males and 14 females, aged from 21 to 55 (mean, 40.7 ± 3.57) years; with body mass index (BMI) of 21-29.6 kg/m$^2$, (mean, 23.5 kg/m$^2$); the causes of injury: 13 cases with traf-fic accident injury and 17 with fall injury; Böhler's angle (8.75 ± 5.5) and Gissane's angle (130.35 ± 32.8); the average time interval from injury to surgery ranged (6.8 ± 1.2) d. 30 cases (30 feet) were in the bone graft group, including 15 males and 15 females, aged from 20 to 54 (mean, 41.2 ± 5.87) years; with the body mass index (BMI) of 21.5-29.8 kg/m$^2$ (mean, 23.7 kg/m$^2$); the causes of injury: 12 cases with traffic accident injury and 18 with fall injury; Böhler's angle ranged (8.67 ± 5.4); and Gissane's angle ranged (130.47 ± 32.8); the average time from injury to surgery ranged (7.1 ± 1.7).

### *Surgical methods*

The patients were given such symptomatic treatment as immobilization, leg-raising or promoting blood circulation to remove blood stasis, and at the same time, they underwent the calcaneus three dimensional CT scans and reconstruction by the same group of surgeons. With the patient placed in lateral decubitus position, pneumatic tourniquet was applied to compress the proximal thigh to control bleeding. The consecutive epidural anesthesia was performed. The "L" shape calcaneal lateral extensile approach was used to incise from tissue to the lateral wall of calcaneal layer by layer. The skin flap was elevated after the sharp dissection was performed under the periosteum, fully exposing the calcaneus lateral wall and the subtalar joint. Firstly, the medial wall was reduced, then the collapsed fracture fragment was pried up to restore the posterior articular surface under the C-arm device.

In the bone grafting group, the bone grafting bones were used to fill the reduced bone defects while the non-bone graft group did not undergo bone grafting. Finally, the lateral wall was restored and was immobilized by the anatomical armor plate. The whole layer incision was sutured and was placed with the incision drainage dermatome.

### *Postoperative treatment*

Patients were given postoperatively conventional antibiotics to prevent infection and immobilized in a plaster back slab and diuretic and repercussive medicine was administered. The incision drainage dermatome was removed within 24 to 48 hours after operation. During the postoperatively bed rest period, the patients were guided with exercise for strengthening the muscles of feet, ankles and toes. The stitches were removed 3 weeks after operation. After wound healing, with the support of double crutches, the patients were allowed to walk with the operated limb bearing no weight. They were allowed to walk with gradual weight bearing after the fracture healing was confirmed by the reviewed X-ray film.

**Table 1.** The comparison of general information between the two groups

| Data | Bone graft group | Non bone graft group |
|---|---|---|
| Age (years old) | 41.2 ± 5.87 | 40.7 ± 3.57 |
| Gender (man/woman, case) | 15/15 | 16/14 |
| BMI (kg/m$^2$) | 23.7 | 23.5 |
| Injury (case) | | |
| Traffic injury | 12 | 13 |
| Falling injury | 18 | 17 |
| Böhler's angle (°) | 8.67 ± 5.4 | 8.75 ± 5.5 |
| Gissane's angle (°) | 130.47 ± 32.8 | 130.35 ± 32.8 |
| The interval time from injury to operation (day) | 7.1 ± 1.7 | 6.8 ± 1.2 |

**Table 2.** Comparison of clinical efficacy between the two groups

| Group | The fracture healing time (week) | Operation time (min) | The rate of the wound adverse reaction (case, %) |
|---|---|---|---|
| Bone graft group | 12.5 ± 3.7 | 81 ± 7.4* | 2 (6.7) |
| Non bone graft group | 11.6 ± 2.9 | 62 ± 6.1 | 1 (3.3) |

Note: compared with none bone graft group, *$P$<0.05.

After to determine the, patients walk gradually with weight-bearing.

*Evaluation criteria*

The patients' pre- and postoperative Böhler's angle, Gissane's angle and calcaneal width were determined by the X-ray films and the calcaneum fracture healing was assessed by reviewing CT imaging examination. According to the Maryland Foot Score (MFS) system, pain (45 points) and function (55 points) were used to evaluate efficacy (excellent defined as 90-100 points, good as 75-89 points, fair as 50-74 points, and poor as <50 points). The ankle joint scoring system visual analogue scale (VAS) and Short Form 36 Health survey Questionnaire (SF-36) of the American Orthopaedic Foot & Ankle society (AOFAS) were employed to evaluate the postoperatively clinical efficacy.

*Statistical treatment*

All the statistical data were analyzed by SPSS 19.0 software. Measurement data was expressed as $\bar{x} \pm S$. The comparison between the groups was made by the t test with the counting data expressed as percentage while the comparison among the groups was performed by the $\chi^2$ test. $P$<0.05 was considered statistically significant.

## Results

*Comparison of general information between two groups*

According to the statistic results, there were no significant differences in general information such as gender, age, BMI, the causes of injury, preoperative Böhler's angles and Gissane's angles, and the time intervel from injury to surgery ($P$>0.05). So the two groups were comparable, as shown in **Table 1**. Postoperatively, the patients in the bone graft group were allowed to walk full weight-bearing until week 8 while the patients in the non-bone grafting group were allowed to do so until week 12.

*Comparison of operation time, fracture healing time and the incidence of impaired wound healing between the two groups*

The mean follow-up in the two groups was 26 months (range 24-30 months), and during this period there was no infection. 2 cases presenting postoperative impaired wound healing or cutaneous necrosis in the bone graft group and one case indicating postoperative impaired wound healing in the non-bone graft group had later healing after dressing change. The operation time of the bone graft group ranged from 78 to 90 min (mean, 81 ± 7.4 min); and the operation time of the non-bone graft group ranged from 60 to 70 min (mean, 62 ± 6.1 min). So the differences in operation time between the two groups were statistically significant ($P$<0.05). According to the postoperative calcaneus CT scans, the patients in both group had excellent fracture healing without obvious heterotopic ossification. The fracture healing time of the bone graft group ranged 12.5 ± 3.7 weeks while that of non bone graft group ranged 11.6 ± 2.9 weeks, so the difference was not statistically significant, as shown in **Table 2**.

**Table 3.** Comparison of preoperative and 2-year postoperative Böhler's angles, Gissane's angles and calcaneal width in the two groups

| Group | Case | Böhler' angles | | Gissane's angles | | Calcaneal width | |
|---|---|---|---|---|---|---|---|
| | | Preoperative (°) | Postoperative (°) | Postoperative (°) | Postoperative (°) | Postoperative (mm) | Postoperative (mm) |
| Bone graft group | 30 | 8.67 ± 5.4 | 24.6 ± 10.7* | 130.47 ± 32.8 | 125.7 ± 8.1* | 36.47 ± 4.8 | 29.1 ± 2.1* |
| Non bone graft group | 30 | 8.75 ± 5.5 | 24.1 ± 11.5* | 130.35 ± 32.8 | 126.6 ± 7.5* | 35.95 ± 4.6 | 28.9 ± 2.5* |

Note: compared with pre-operation, **P*<0.05.

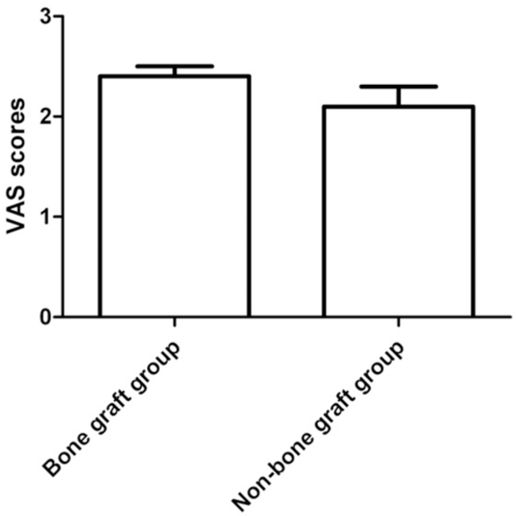


**Figure 1.** Comparison of VAS scores in two groups in 2 year after operation.

*Comparison of Böhler's angles, Gissane's angles and calcaneal width between the two groups*

Preoperatively, the Böhler's angles in the bone grafting group and non-bone grafting group were 8.67 ± 5.4 and 8.75 ± 5.5 respectively and they were postoperatively 24.6 ± 10.7° and 24.1 ± 11.5, respectively. The postoperative Böhler's angles in both groups were obviously improved and there was statistically significant difference (*P*<0.05). The differences in the postoperative Böhler's angles were not statistically significant between the two groups (*P*>0.05). The preoperative Gissane's angles of the two groups were 125.7 ± 8.1 and 126.6 ± 7.5, respectively and they were postoperatively 130.47 ± 32.8, and they were postoperatively 130.35 ± 32.8, respectively. The postoperative Böhler's angles were significantly improved compared to preoperative ones and there was statistically significant difference (*P*<0.05); while the postoperative difference between the two groups was not statistically significant (*P*>0.05). The preoperative calc-aneal width in the two groups was 36.47 ± 4.8 mm and 35.95 ± 4.6° mm respectively, while postoperatively was (29.1 ± 2.1) mm and (28.9 ± 2.5) mm, respectively. Compared to the preoperative calcaneal width, the postopera-tive width were remarkably improved. There was statistically significant difference (*P*<0.05); while the postoperative differences were not statistically significant (*P*>0.05), as seen in **Table 3**.

*Comparison of VAS and SF-36 scores between the two groups*

Postoperatively, the VAS score of patients in the bone graf group was 2.4 ± 0.1 while in the non-bone graft group was 2.1 ± 0.2. The differences in VAS score between the two groups were not statistically significant, as shown in **Figure 1**. Six months after operation, the differences in SF-36 score between the two groups were not statistically significant. However, one or two years after operation, the SF-36 score of the bone graft group was obviously higher than that of the non-bone graft group, and the difference was statistically significant (*P*<0.05), as shown in **Table 4**.

*Comparison of postoperative Maryland foot scores between the two groups*

Two years after operation, the clinical outcome was evaluated in terms of the Maryland foot score criteria: 17 out of the 30 cases in the bone graft group were excellent and 9 cases were good, with an excellent and good rate of 86.7%; 17 out of 30 cases in the non-bone graft group were excellent and 8 cases were good, with an excellent and good rate of 86.7%. There were no significant differences in the excellent and good rate between the two group (*P*>0.05). The differences in the excellent and good rate (the Maryland score) between month 6 (70% vs 66.7%) and year 1 (80% vs 73.3%)

**Table 4.** Comparison of SF-36 scores between the two group

| Group | Case | SF-36 score | | |
|---|---|---|---|---|
| | | 6 months after operation | 1 year after operation | 2 years after operation |
| Bone graft group | 30 | 70.6 ± 7.4 | 79.4 ± 6.7* | 82.6 ± 6.1* |
| Non bone graft group | 30 | 68.7 ± 7.5 | 72.1 ± 6.5 | 74.3 ± 6.3 |

Note: compared with none bone graft group, *$P$<0.05.

after the operation of the two groups were not statistically significant, as shown in **Table 5** and **Figure 2**.

## Discussion

The calcaneus is mainly composed of cancellous bone and most of calcaneal fractures are caused by high energy injuries, which can be divided into joint fracture and intra-articular fracture in terms of the involvement of the surface of subtalar joint. Intra-articular fracture can be classified into different sanders types in terms of the CT scans at the coronal site or the axial plane of the posterior articular surface. The Sanders III fracture is displaced in the three parts of posterior articular surface and there are two fracture lines along the posterior articular surface. When the articular surface of Sanders III fracture calcaneal fracture collapses seriously, improper management may result in unsmooths joint surface or poor reduction of the articular surface, leading to such complications as heel pain, joint dysfunction and traumatic arthritis, even walk inconvenience or claudication [9, 10].

Most of the calcaneal fractures are collapse fractures, and fracture reduction usually accompany with obvious bone defects. Currently, there is a controversy about whether sanders III calcaneal fractures need bone grafting. Some studies have argued that the bone graft play the roles of creeping substitution and support for the collapsed articular surface and bone mass, preventing secondary calcaneal collapse or fracture nonunion [11, 12]. And other studies have showed that using bone graft in local bony defects is helpful to restore the initial compressive strength of the joint, leading to early full weight-bearing [13, 14]. In addition, the calcaneal bone is mainly composed of cancellous bone, which is reticular porous and of abundant blood circulation. Bone sclerotin defects may bleed, which in turn results in delayed wound healing even infection. Bone grafting can reduce the amount of bleeding and the incidence of infection [15, 16]. Large bony defects often present after reduction of sanders type III calcaneal fracture. Although the use of locking plate fixation can make up for some of the adverse effects of bony defects, bone graft is still in need in the case because the bone grafting increases the holding power of the internal fixation screws, and gives effective support for the reduced posterior articular surface [17, 18]. The scholars opposing bone graft believe that bone defects present in the central triangle of calcaneal fractures. In most cases, there is no need of bone graft because the fractured site is osteoporotic, which fails to make mechanical support. Besides, calcaneus has a strong regeneration, so bone graft does no need in most situations [19]. Another study reported that, owing to the vascular abundance in the calcaneus, open reduction and internal fixation had a better contraposition for calcaneal cortical area. If there was only a small hole left, there was no need for bone grafting because the instability of grafted bone blocks might be accountable for bone shifting, even oppressing tendons and nerves [20]. Thus, only when bone defects is too serious to fixate and support the contraposition and resetting of posterior articular facet, is the need of bone grafting considered.

Recently, most of the studies have reported that 6-10 weeks after the treatment of bone grafting, the patients with calcaneal fractures could start full weight-bearing functional exercise [21]. Studies also have shown that anatomical plate treatment combined with bone graft treatment enabled the patients with calcaneal fractures start full weight-bearing functional exercise 4 weeks after operation, and there were no such complications as significant articular surface re-collapse or reduction loss at the follow-ups [22]. In this study, the patients also underwent functional exercise, and the results showed that the bone graft group began full weight-bearing functional exercise 8 weeks after the operation while the non-bone graft group was able to do that 12 weeks after the operation. The results of this

**Table 5.** Comparison of the excellent and good rate postoperative of the Maryland scores between the two groups (example)

| Group | 6 months after operation | | | | 1 year after operation | | | | 2 years after operation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Excellent | Good | Secondary | Bad | Excellent | Good | Secondary | Bad | Excellent | Good | Secondary | Bad |
| Bone graft group | 15 | 8 | 5 | 2 | 16 | 8 | 4 | 2 | 17 | 9 | 4 | 0 |
| Non bone graft group | 13 | 7 | 8 | 2 | 15 | 7 | 6 | 2 | 17 | 8 | 4 | 1 |

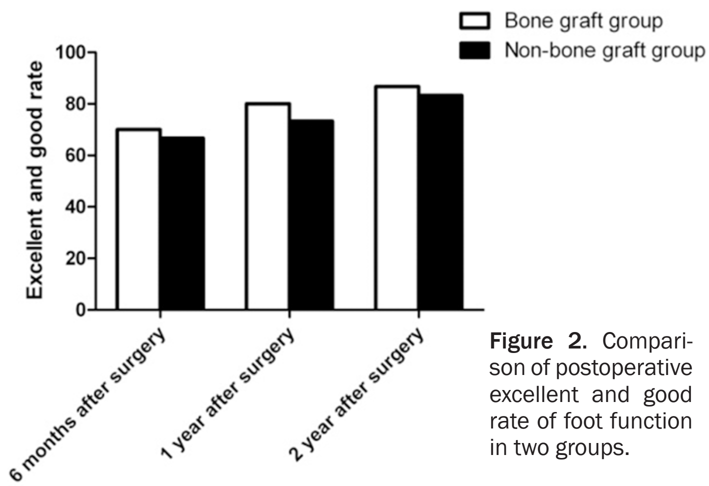


**Figure 2.** Comparison of postoperative excellent and good rate of foot function in two groups.

study showed that the postoperative recovery of Böhler's angle, Gissane's angle and calcaneal width between the bone graft group and the non-bone graft group was not significantly different. With the increasing follow-up time, the comparison of foot disorder scores between the two groups also showed no significant difference. And there was no statistical difference in the VAS scores of the two groups of patients at the final follow-up. However, the SF-36 scores for 1 year and for 2 years after operation in the bone graft group were higher than those of the non-bone graft group and the difference was statistically significant ($P<0.05$).

Thus, it shows that the bone graft is of importance for postoperative patients to start functional exercise earlier and improve life quality. The bone grafting enhances earlier compressive strength of posterior articular facet of calcaneus and ensures evenness of the articular surface and height of calcaneus after operation. As a result, there won't be significant complications like articular surface collapse or reduction loss in the early full weight-bearing after bone grafting, and it won't result in the difference of foot function scores. Therefore, it is necessary for people who are with sanders III calcaneal fractures complicated by serious bone defects, who desire to start heavy-bearing walking earlier, or those who engage in heavy manual work are necessary to undergo open reduction and internal fixation combined by bone grafting.

There have been some limitations in this research: the small selected sample size and the single center study. Further studies need collecting more cases and multicenter follow-up prospective control studies are required for further demonstration.

## Disclosure of conflict of interest

None.

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