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## Change in Bohler and Gissane angles following open reduction and internal fixation without bone grafting for closed sanders type 2 and 3 calcaneal fractures

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### Abstract

**Background:** Use of bone graft or bone graft substitutes during open reduction and internal fixation of the fractures of the calcaneum is controversial. The present study was an endeavor to evaluate the postoperative change in Bohler and Gissane angles after open reduction and internal fixation without bone grafting of Sanders type 2 & 3 fractures of the calcaneum.

**Method:** 22 cases of closed Sanders type 2 and 3 fracture of the calcaneum were operated by open reduction and internal fixation with calcaneal locking plates without bone grafting. The change in Bohler and Gissane angles from immediate post-operative period to a follow up of 3 and 6 months was measured. AOFAS score was evaluated at 6 months follow up.

**Results:** Out of 22 cases 3 were lost to follow up in the initial 3 months and 1 was lost to follow up after 3 months. A statistically significant change in Bohler and Gissane angles from preoperative to post-operative period was found the change in Bohler and Gissane angle from immediate post-operative period to 3 months follow up was not statistically significant. The change in Bohler and Gissane angle from immediate post-operative period to 6 months follow up was also not statistically significant. At 6-month follow-up, mean AOFAS score of 18 cases was 81.7 (range 58-98). 4 patients had excellent result, 11 had good result and 3 patients had fair result and no patient had poor result. The average AOFAS score of 18 cases was 81.7 (range 58-98) at 6-month follow-up. 4 patients had excellent result, 11 had good result and 3 patients had fair result and none had poor result.

**Conclusion:** The present study had a low wound complication rate, good functional score, absence of bone graft donor site morbidity and allograft complications. It did not show statistically significant change in the Bohler and Gissane angles even at 6 months follow up, thereby implying that there is no loss of reduction of the fracture in the absence of bone grafting.

**Keywords:** Calcaneal fractures, Sanders type 2 & 3, Bohler and Gissane angles

### 1. Introduction

The management of fractures of calcaneum has been controversial as there is no consensus among orthopedic surgeons regarding management of these fractures. In general Sanders type 1 fractures can be managed non-operatively while Sanders type 2, 3, 4 fracture of the calcaneum can be treated by open reduction and internal fixation with or without bone grafting [1-4]. However, Sanders type 4 fractures have inferior results irrespective of being managed operatively or non-operatively [2]. Use of bone graft or bone graft substitutes during the open reduction and internal fixation of fractures of calcaneum is controversial. Some authors believe that bone grafting is not necessary in every case, particularly because the defect that remains after reduction of a fracture is similar in location to the neutral triangle of the calcaneum, where little structural bone integrity is normally found [5]. Recent literature suggests that open reduction and fixation of fractures of calcaneum have similar results irrespective of the use of bone graft [6]. The present study was an endeavor to evaluate the postoperative change in Bohler and Gissane angles after open reduction and internal fixation without bone grafting of Sanders type 2 & 3 fractures of calcaneum.

### 2. Materials and Methods

#### 2.1 Study Design

A prospective study was conducted in the department of Orthopedics, UCMS and GTB

Hospital, Delhi. 21 adults with closed Sanders type 2 and 3 calcaneal fractures presenting within 15 days of injury were included in the study. An ethical clearance was taken from the ethics committee of the institution. A written informed consent was taken from each of the patients for inclusion into the study. Patients with diabetes mellitus, peripheral vascular diseases, paraplegia, and those on drugs that affect fracture healing like steroids and anti-cancer drugs and those unwilling to participate in the study were excluded.

After clinical assessment and stabilization of the patient, plain radiographs of the affected heel (axial and lateral views) were taken. A Computed Tomography (C.T.) scan of the heel was done to classify the fracture based on Sanders classification. A below knee splint and limb elevation was given to all patients until the wrinkle sign appeared after which the patients were taken up for surgery. All patients were operated using the standard technique with the extensile lateral approach using calcaneal locking plate without bone grafting [3, 5, 7]. Patients were encouraged to do active toe and ankle mobilization in the immediate post-operative period. Wound inspection was done on the second post-operative day and subsequently depending on the status of wound. Patients were allowed mobilization with the help of crutches with no weight bearing on the operated limb for 3 months. The patients were encouraged to do gradual weight bearing after 3 months. AOFAS score at 6 months follow up was evaluated. The American Orthopaedic Foot and Ankle Society Score (AOFAS) Ankle-Hind foot Scale has excellent defined as 90–100 points, good as 75–89 points, fair as 50–74 points, and poor as <50 points [8].

Lateral radiograph of heel were taken at immediate post-operative period, 3 months and 6 months follow up and their Bohler and Gissane angles were measured using Adobe Photoshop CS5 software. These measurements were done by two observers (ANA and TK) independently at different time.

## 2.2 Statistical analysis

The mean of these values obtained by these two observers for a particular radiograph was used for statistical analysis. This analysis was done using the Paired t-test and ANOVA using the Windows SPSS (version 14) software.

## 3. Observation and results

### 3.1 Patient characteristics

A total of 22 calcaneum (21 patients) were operated. Their results are depicted in Table 1. Out of these, three patients (case 1, 18 and 19) were lost to follow up in the initial three months while one patient (case 14) was lost to follow up after three months. For statistical analysis the 3rd month result of case 14 was taken as the 6th month reading as we expected no change while case 1, case 18 and case 19 were not analyzed in the follow up. We had a maximum follow-up up to 1 year in 10 patients. The patient's mean age was 32.1 years (range 21–50 years). There were 14 males and 7 females. One patient had bilateral fracture (case 7 and 8) hence 22 calcaneal fractures in 21 patients were included in the present study. Six cases (27.3%) were Sanders type 2 and 16 cases (73.7%) were Sanders type 3. The median injury surgery duration was 9 days (range 5–13 days).

**Table 1:** Details of the clinical cases

S.no	Age	sex	side	Sanders type	ISD	B0	G0	B1	G1	B3	G3	B6	G6	AOFAS score	complications
1	21	M	right	3	6	1.1	127.9	39.7	111.9						
2	34	M	left	3	5	12	79.7	32.2	107	31.2	106.8	31.5	109	85	delayed wound infection at 1 year
3	30	M	left	3	13	6.2	98.3	38	106	35.8	120.4	35.2	107.2	77	peroneus brevis cut
4	45	M	right	3	13	18.7	99.6	32.5	107.4	30.1	103.1	31.3	104.4	78	
5	28	F	left	3	11	7.4	82.4	23.4	106.5	25.4	108.2	23	109.5	85	delayed wound healing
6	35	M	right	2	8	23	111.1	25	110	24.2	111	24	112.3	88	
7	35	M	right	3	12	26.6	99.7	31.5	100.7	29.7	101.5	24.1	108.2	82	
8	35	M	right	3	12	12.8	106.2	34.8	106.6	34.2	107.2	34.9	110.4	82	
9	22	F	right	3	11	42.5	92.2	51	117.4	34.2	118.4	45.8	117.6	73	
10	38	M	right	3	11	14.3	67.1	20.5	112	19.3	122	21.6	122.4	59	wound breakdown post operatively
11	50	M	right	3	7	13.4	120.9	29.3	113.2	29.9	113.1	30.2	116.2	74	delayed wound healing, Sural nerve hypoaesthesia
12	32	F	left	2	12	15.8	110.1	33.3	113.5	34.3	112.8	34	112.4	85	delayed wound healing, implant prominence
13	30	M	right	3	8	22.8	117.4	30.4	115	29.8	113.7	28.5	113.5	95	delayed wound healing
14	35	F	left	2	8	5.1	100	20.5	117.8	15.3	116.8				
15	24	M	left	2	9	12.8	117.4	23.2	119.3	21.6	117	21.9	115.7	98	
16	30	F	left	3	6	6.2	58.3	25.5	114	23.4	112.2	25.1	116.2	58	wound breakdown post operatively
17	31	M	left	3	9	14.8	115	32	110	29	108.4	27	106.1	90	
18	35	M	left	3	11	11.8	118	29.3	118.2						
19	27	M	left	3	9	2.5	118.5	26.7	118.5						
20	35	F	right	2	7	4.8	92.7	23.5	100.7	24	103.1	23.1	105.3	75	
21	30	M	left	3	11	8.8	128	20.6	129.7	21.1	133.7	20.7	133.1	88	
22	24	F	right	2	8	19.7	92.7	35.2	110	33.9	112.3	33.7	114	98	

ISD: Injury surgery duration; B0: Pre-operative Bohlers angle; G0: Pre-operative Gissane angle; B1: Immediate post-operative Bohler angle; G1: Immediate post-operative Gissane angle; B3: Bohler angle at 3 months follow-up; G3: Gissane angle at 3 months follow up; B6: Bohler angle at 6 months follow up; G6: Gissane angle at 6 months follow up.

### 3.2 Bohler and Gissane angles

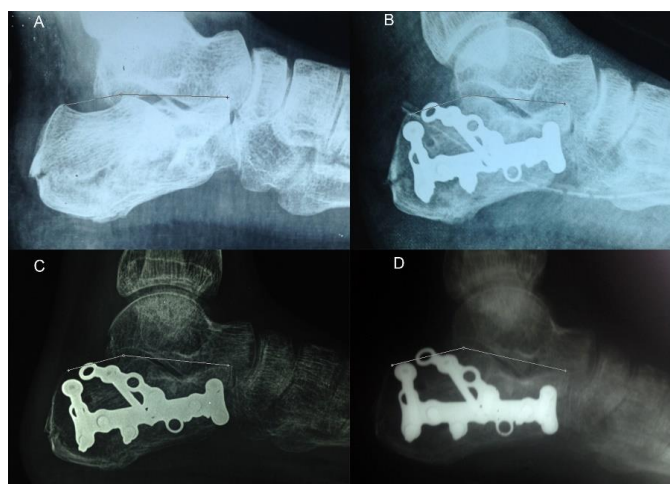
The mean observed Bohler and Gissane angles at various follow ups are depicted in table 2. The pre-operative Bohler and Gissane angles were compared to the post-operative Bohler and Gissane angles using the Paired t-test. The change between pre-operative Bohler and post-operative Bohler angle

was statistically significant ( $p=0.000$ ). The change between pre-operative and post-operative Gissane was also found to be statistically significant ( $p=0.016$ ). The General Linear Model, repeated measures analysis of variance (ANOVA) was used, taking the pre-operative angles as covariate.

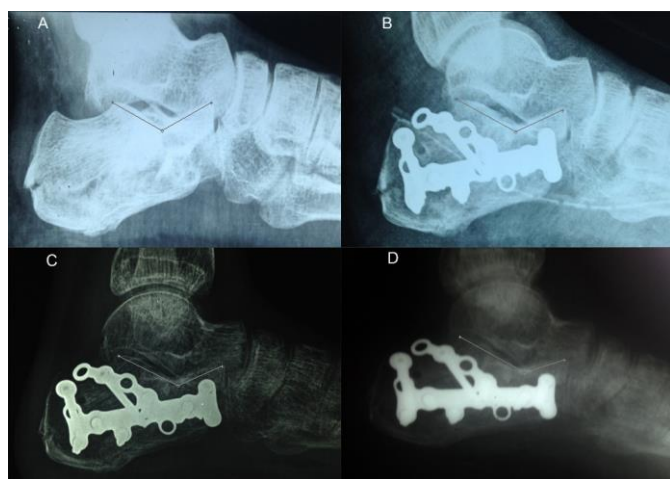
**Table 2:** Angles measured

Time frame	Bohler angle	Gissane angle
Pre-operative (n=22)	13.8° (SD- 9.4°)	102.4°(SD-18.7°)
Immediate Post-operative (n=22)	29.9°(SD-7.4°)	112.1°(SD-6.7°)
3 months follow up (n=19)	27.7°(SD-5.9°)	112.7°(SD-7.7°)
6 months follow up (n=18)	27.9°(SD-7.1°)	113.2°(SD-6.8°)

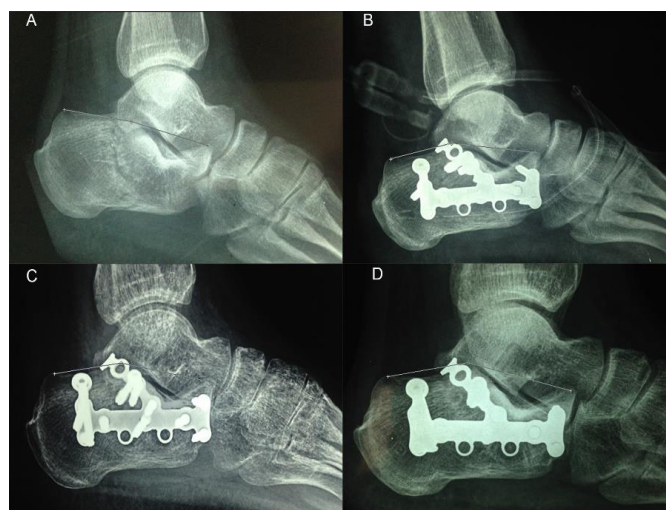
The post-operative angles were compared to 3 months and 6 months follow up. The change in Bohler angle from immediate post-operative period to 3 months follow up was not statistically significant ( $p=0.108$ ). The change in Bohler angle from immediate post-operative period to 6 months follow up was also not statistically significant ( $p=0.990$ ). The change in Gissane angle from immediate post-operative period to 3 months follow up was not statistically significant ( $p=0.249$ ). The change in Gissane angle from 3 months follow up to 6 months follow up was also not statistically significant ( $p=0.715$ ). The average AOFAS score of 18 cases was 81.7 (range 58-98) at 6-month follow-up. 4 patients had excellent result, 11 had good result and 3 patients had fair result and none had poor result. Case 1, 14, 18 and 19 were lost before 6 months follow up. Representative serial follow up of Sanders type 3 fracture (case 21) is depicted in figures 1 and 2 and Sanders type 2 fracture (case15) is depicted in figures 3 and 4.



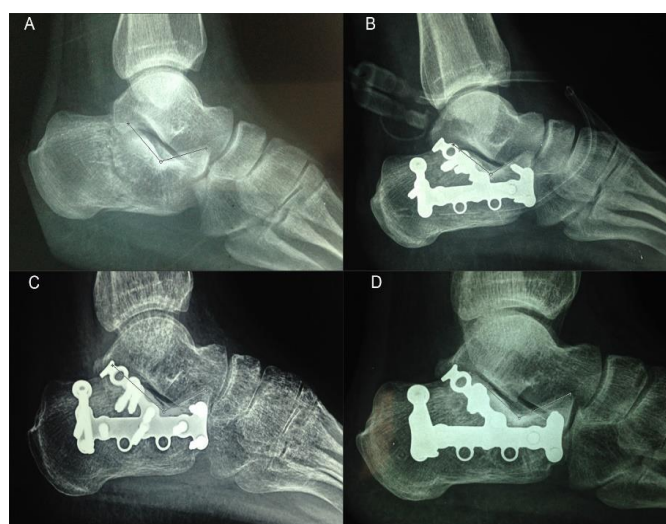
**Fig 1:** A) The pre-operative Bohler angle was 8.8°; B) Immediate post-operative Bohler angle was 20.6°; C) The Bohler angle at 3 months follow up was 21.1°; D) The Bohler angle at 6 months follow up was 20.7°



**Fig 2:** A) The pre-operative Gissane angle was 128°; B) Immediate post-operative Gissane angle was 129.7°; C) The Gissane angle at 3 months follow up was 133.7°; D) The Gissane angle at 6 months follow up was 133.1°



**Fig 3:** A) The pre-operative Bohler angle was 12.8°; B) Immediate post-operative Bohler angle was 23.2°; C) The Bohler angle at 3 months follow up was 21.6°; D) The Bohler angle at 6 months follow up was 21.9°



**Fig 4:** A) The pre-operative Gissane angle was 117.4°; B) Immediate post-operative Gissane angle was 119.3°; C) The Gissane angle at 3 months follow up was 117°; D) The Gissane angle at 6 months follow up was 115.7°

### 3.3 Complications

The various complications encountered during surgery and follow up were

- **Intraoperative:** In 1 patient (case3) peroneus brevis tendon was cut during surgery. It was repaired using non-absorbable suture.
- **Immediate Post-operative:** 3 patients (case 5,11 and 13) had delayed wound healing
- **Wound breakdown:** 2 patients (case10 and 16) had wound breakdown in the post-operative period. They were managed by regular dressing and the wound eventually healed.
- **Sural nerve hypoaesthesia:** 1 patient (case11) developed hypoaesthesia in the sural nerve distribution following the surgery.
- **Delayed infection:** 1 patient (case2) presented with delayed surgical site infection 1 year after the index surgery. Debridement and implant removal was performed.
- **Implant Prominence:** 1 patient (case12) had complaints of prominent hardware. The implant was removed at 1-year follow up.



## 4. Discussion

### 4.1 Comparison with literature

Many authors believe that displaced intra-articular fractures of the calcaneum should be treated on the same principles as any other intra-articular fracture i.e. anatomical reduction and stable internal fixation [9, 10]. Improved surgical techniques and better implants have reduced the complication rates of surgery, which has led many surgeons to advocate operative treatment of these fractures. The necessity of bone grafts in the treatment of intra-articular calcaneal fractures is a debated topic in foot and ankle surgery [6]. Proponents of bone grafts believe that it could increase stimulation of fracture healing for early full weight bearing, prevent post-traumatic arthritis, and add mechanical strength to avoid significant late collapse [11]. Those opposed to bone grafts state that the highly vascular calcaneum heals radio-graphically 4-8 weeks after surgery even in the absence of bone graft, where internal fixation could adequately support the articular surface [12-15]. Bone grafting would increase the infection rate, blood loss, and postoperative pain and also has the inherent donor site morbidity and complications of auto-graft [6].

Longino *et al.* compared 20 patients with displaced intra-articular calcaneal fractures operated with open reduction and internal fixation and bone graft with 20 patients operated with open reduction and internal fixation only. 15 cases were Sanders type 2, 21 were Sanders type 3 and 4 were Sanders type 4. They found no significant difference between the changes in Bohler angle in the 2 groups at 3 months follow

up. However, they did not measure the change in Bohler angle at 6 months follow up [16]. Johal *et al.* in a study on 52 calcaneal fractures found no change in Bohler angle at 6 weeks and 3 months follow up between 2 groups, one treated with open reduction and internal fixation without bone grafting and the other with open reduction and internal fixation along with bio-resorbable bone substitute material calcium phosphate paste (Alpha-BSM). However, they showed a statistically significant change in Bohler angle in 6 months and 12 months follow up in the non-bone graft group. However, there was no difference between the two groups in regards to secondary outcome measures of general health, limb specific function, and pain at 2 years follow up [17]. In the current study, we found no statistically significant change in the Bohler and Gissane angles even at 6 months follow up unlike the previously mentioned study. Weber *et al.* treated 26 patients by open reduction and internal fixation without bone grafting using the extensile lateral approach. In none of their patients the Bohler angle changed more than 5°. They reported that due to rotational differences during the exposure for radiographs, change in angles <5° maybe inherent error of measurement [18]. In the current study, three patients had a change of more than 5° from 0 to 6-month follow-up (case 9 and 14: 5.2°; case 7: 7.4°). Table 3 gives a comparison of the change in Bohler angle published in various studies since the beginning of century. They include studies that involved autogenous bone grafting, bone grafting substitutes and without the use of bone grafts.

**Table 3:** Change in Bohler angle in follow-up

Study	Bone graft	Post-operative Bohler angle /(fractures)	Follow up Bohler angles/(fractures)	Average Change /(fractures)
Longino <i>et al.</i> (2001) [16]	With bone graft	26°/(20)	19°/(20)	7°/(20)
Johal <i>et al.</i> (2009) [17]	with bone graft substitute	Not mentioned	Not mentioned	6.2°/(26)
Yang <i>et al.</i> (2012) [6]	Meta-analysis with bone graft	28.4°/(239)	25.1°/(224)	3.7°/(134)
Longino <i>et al.</i> (2001) [16]	Without bone-grafting	27°/(20)	21°/(20)	6°/(20)
Johal <i>et al.</i> (2009) [17]	Without bone grafting	Not mentioned	Not mentioned	10.4°/(26)
Yang <i>et al.</i> (2012) [6]	Metanalysis without bone graft	27.1°/(270)	24.0°/(111)	5.9°/(89)
Current Study	Without bone grafting	29.9°/(22)	27.9°/(18)	1.7°/(18)

### 4.2 Complication rate

Operative treatment of fracture calcaneum has a significant complication rate. The wound complication rate of the current study was compared to other available studies in table 4.

**Table 4:** Complication rates

Study	Wound complication rate
Tennent <i>et al.</i> (2001) [19]	0.3%
Geel <i>et al.</i> (2001) [13]	22%
Buckley <i>et al.</i> (2002) [20]	15.9%
Gupta <i>et al.</i> (2003) [21]	6%
Herscovici <i>et al.</i> (2005) [22]	13.6%
Pendse <i>et al.</i> (2006) [23]	3.3%
Vaclav <i>et al.</i> (2012) [24]	10.5%
De Groot <i>et al.</i> (2013) [25]	32%
Xiao Yu <i>et al.</i> (2014) [26]	13.6%
Current Study	9.1%

### 4.3 AOFAS score

The AOFAS score is considered the gold standard for assessment in calcaneal surgery. The AOFAS score in the current study was compared to other available studies of treatment without bone grafting since the beginning of this century in table 5. The meta-analysis by Yang *et al.* showed a

mean AOFAS score in patients treated without bone graft to be 80.5 while the current study had a mean score of 81.7% [6].

**Table 5:** AOFAS scores

Study	Excellent	Good	Fair	Poor
Ebraheim <i>et al.</i> (2000) [12]	38.8%	36.7%	13.2%	11.3%
Grala <i>et al.</i> (2009) [27]	26.2%	66.7%	0	7.1%
Makki <i>et al.</i> (2010) [15]	38.3%	36.2%	6.3%	19.2%
Current study	22.2%	61.1%	16.7%	0

### 4.4 Limitations of the study

The sample size was small due to limitation of the study period. The present study has limited duration of follow up i.e. 6 months. No control group was available.

## 5. Conclusion

From the various studies in literature bone graft does not seem to be essential in the operative treatment of Sanders type 2 and 3 fractures. The present study showed a statistically significant difference between pre-operative and immediate post-operative Bohler and Gissane angles. However, no significant difference was found in the change in Bohler and Gissane angles when immediate post-operative values were compared to 3 months follow up and when 3 months follow

up was compared to 6 months follow up. The present study had a low wound complication rate, good functional score, absence of bone graft donor site morbidity and allograft complications. And it did not show a statistically significant change in the Bohler and Gissane angles even at 6 months follow up thereby showing that there is no loss of reduction of the fracture even in the absence of bone grafting.

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