

# Effect of Sustentaculum Screw Position on Outcomes of Intraarticular Calcaneal Fracture Treated with Screw Only Technique

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**Background:** Placement of sustentaculum screws is an important procedure in calcaneal fixation. Inaccurate position may decrease stability of the fixation.

**Purpose:** The aims of this study are to evaluate the effect of sustentaculum screw position on the decrease of Bohler's angle and FAAM (Foot and Ankle Ability Measure) score.

**Materials and Methods:** Retrospective review of patients who underwent operative fixation of calcaneus fracture using screw only technique through sinus tarsi approach between July 2017 to March 2020 in Maharat Nakhon Ratchasima hospital. Postoperative sustentaculum screw positions were assessed with 3D-CT scan. Position of screws were grouped into good fixation (screw placed on cortical area of sustentaculum tali) and poor fixation group (screw placed out of cortical area of sustentaculum tali). The postoperative and 6-month follow-up Bohler's angles were compared. The FAAM was used to evaluate the clinical outcome at 6 months.

**Results:** 38 patients (7females and 31males) with mean age of  $48 \pm 11.6$  were reviewed. The age of patients, preoperative Bohler's angles and type of fractures showed no significant difference between two groups of the sustentaculum screw position. Postoperative 3D-CT scan classified 13 cases into the good fixation and 25 cases into the poor fixation groups. The decrease of Bohler's angle and FAAM score at 6 months showed no statistically difference between two group ( $P > 0.05$ ).

**Conclusions:** Position of the sustentaculum screw do not show statistical difference of the decrease of Bohler's angle and FAAM score in operative treatment of intraarticular calcaneal fracture using screws only technique.

**Keywords:** Sustentaculum screw, Radiographic outcome, Clinical outcome

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## Introduction

Calcaneus is the most common tarsal bone fracture which accounts for 60%-65% of the entire tarsal bone fractures and approximately 75% are intra-articular fracture<sup>(1,2)</sup>. Displaced intra-articular calcaneal fracture often treated with operative management to prevent poor functional outcome and late subtalar arthrodesis<sup>(3)</sup>.

The sustentacular fragment (constant fragment) is important to operative fixation of subtalar joint since it usually maintains its position via the strong interosseous talocalcaneal and deltoid ligaments to talus<sup>(4)</sup>. Screw is used to fix sustentacular fragment from lateral to medial side beneath posterior facet joint. Optimal positioning of screw is difficult because of complex subtalar joint anatomy and surrounding soft tissue<sup>(5)</sup>. Medial incisions can provide a direct visualization in the medial wall to correct placement of screw but the skin blood supply and neurovascular structure on

medial side might be a problem. The screw could also pass through the lateral plate which biomechanical study indicated that higher strength of the construct, when the sustentaculum screw is used through the lateral plate<sup>(6)</sup>. In cadaveric study, several authors recommend the angle of sustentaculum screw placement from lateral to medial side but still difficult to achieve the optimum position of screw<sup>(7,8)</sup>. Intraoperative fluoroscopic in Harris heel view 20-50 degree could use to access the accuracy of screw placement but it is difficult to take fluoroscopic assessment at precise angles intra-operatively<sup>(9,10)</sup>.

Postoperative CT imaging is more reliable than plain radiography to evaluate the quality of reduction and hardware positioning, especially the sustentaculum screw position<sup>(11)</sup>. Minfei Qiang et al. evaluated the effect of sustentaculum screw when using lateral locking plate by postoperative CT imaging, they found that the poor fixation group may cause the decrease of Bohler's angle postoperatively<sup>(12)</sup>.

The most common operative fixation for calcaneal fracture at Maharat Nakhon Ratchasima hospital is screws only technique through the sinus tarsi approach. Screws only technique has been

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found effective treatment for calcaneal fracture compared with locking plate<sup>(13)</sup>. The purpose of this study is to evaluate the radiological and clinical outcomes of patients with different fixation status of the sustentaculum screw after ORIF of intra-articular calcaneal fractures using screws only technique.

## Patients and Methods

### 1. Patients

We performed a retrospective review of intra-articular calcaneal fractures receiving surgical treatment between June 2017 and March 2020 at Maharat Nakhon Ratchasima hospital. The inclusion criteria were as follows: (1) unilateral, closed intra-articular calcaneal fractures displaced more than 2 mm; (2) age 15 - 70 years old; (3) patients who were treated by ORIF via sinus tarsi approach with 3.5 mm cortical screws only technique (Figure 1). Patients with bilateral calcaneal fractures, open fractures, or multiple traumas were excluded. All clinical data were obtained from medical records. The CT scan, radiographic data and clinical outcome were from the medical image database in the hospital. The study was approved by the institutional review committee of the hospital.

### 2. Radiographic assessment

The CT data was obtained from PACs. The 3D reconstructions were used to observe the position of the sustentaculum screw. The position of the screws was assessed by one attending surgeon who performed operation and grouped as follows:

Group I (Good fixation group): The screw was inserted from lateral to medial of posterior facet and the tip of screw placed on the cortical area of

sustentaculum tali (Figure 2A). This group is the accurate fixation.

Group II (Poor fixation group): The screw was inserted from lateral to medial of posterior facet but the tip of screw placed out of the cortical area of sustentaculum tali (Figure 2B). This group is the inaccurate fixation.

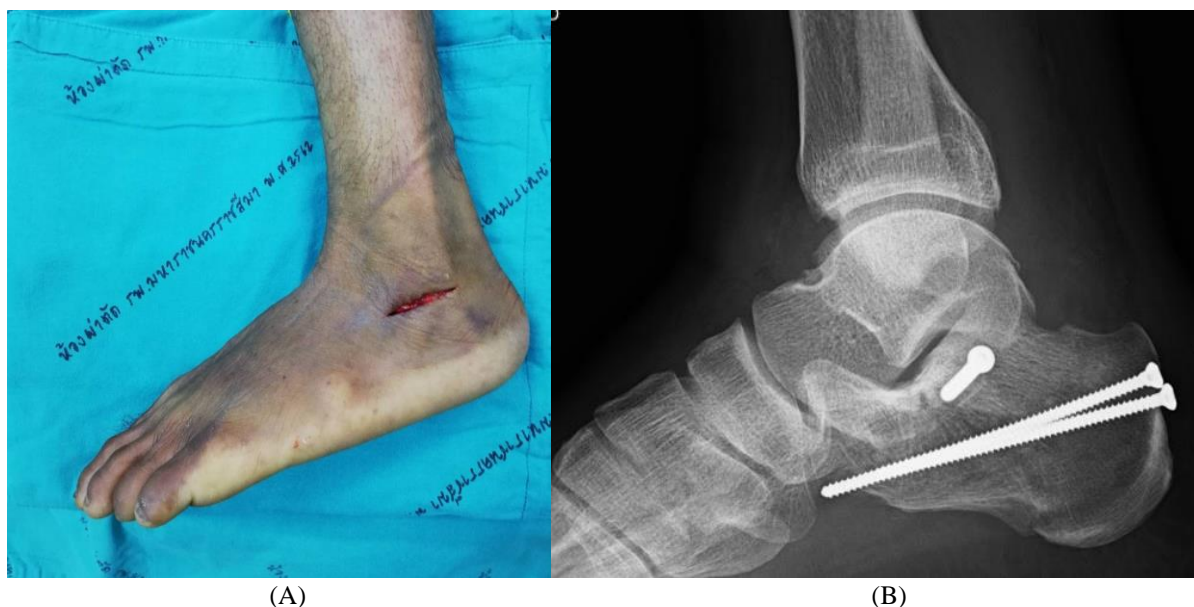
Bohler's angles were evaluated by radiologist and experienced orthopedic resident. The postoperative and 6-month follow-up Bohler's angles were compared.

### 3. Clinical outcome evaluation

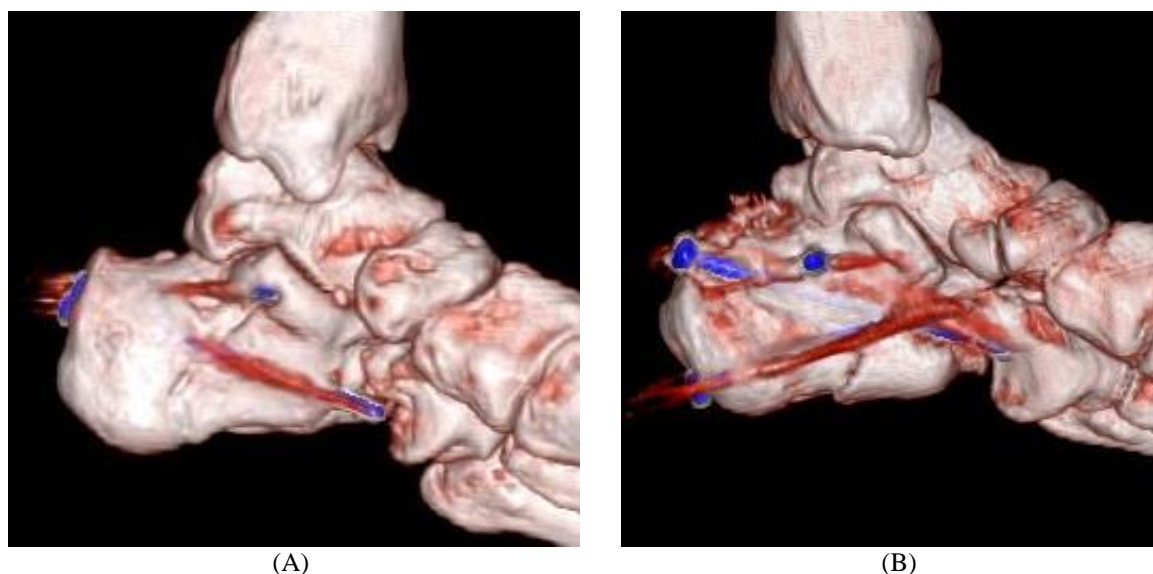
Thai Version of the Foot and Ankle Ability Measure (FAAM) self-report of physical function was used to evaluate the clinical outcome at 6 months. Data was collected from OPD cards. FAAM has proved validity and reliability that it can be used for the evaluation of the physical function, symptoms, and activities in Thai patients with foot and ankle-related problems. The FAAM score classified as excellent (90-100 points), good (80-90points), fair (70-80points) and poor (less than 70 points)<sup>(14)</sup>.

### 4. Data analysis

The data were analyzed using STATA version15. Age and preoperative Bohler's angle were presented with means  $\pm$  standard deviation and compared by independent samples t-test. Fracture type, sustentaculum fixation type data were present with number count and compared by fisher exact test. The difference of Bohler's angle and FAAM score between two groups were determined by t-test. Statistical significance was set at  $P < 0.05$ .



**Fig. 1** (A) Clinical picture demonstrating sinus tarsi approach on lateral decubitus position. (B) Postoperative lateral radiographic demonstrating fixation construction.



**Fig. 2** Postoperative CT with 3D reconstruction on medial side shows fixation types of sustentaculum tali screw. (A) “Good fixation” group which screw (blue color) placed on the cortical area of sustentaculum tali. (B) “Poor fixation” group which screw placed out of the cortical area of sustentaculum tali.

## Result

Thirty-eight patients (7 females and 31 males) with mean age of  $48 \pm 11.6$  are included in our study. Mean preoperative Bohler's angle was  $10.6 \pm 8.3$  (good fixation  $8.8 \pm 8.9$ , poor fixation  $11.8 \pm 8$ ) and mean postoperative Bohler's angle was  $23.7 \pm 6.9$ . There are no statistically significant differences between good fixation and poor fixation groups both preoperative and postoperative Bohler's angles. The fractures have been classified using the Essex-Lopresti system consisting of 19 joint depression and 19 tongue types. 26 type II and 12 type III were classified with the Sanders classification system. The age of patients and type of fractures showed no significant difference between two groups of the sustentaculum tali screw position ( $P > 0.05$ ). (Table 1)

Postoperative 3D-CT scans were evaluated to determine the group of sustentaculum tali screw fixation. There were 13 cases in the good fixation group and 25 cases in the poor fixation group. The postoperative Bohler's angle between two groups showed no significant difference ( $P > 0.05$ ). The decrease of Bohler's angle was greater in the poor fixation group (poor fixation  $2.2 \pm 1.7$ , good fixation  $1.9 \pm 1.4$ ) but not statistically different ( $P > 0.05$ ).

The FAAM score at 6 months is better in the poor fixation group (poor fixation  $84.1 \pm 13.5$ , good fixation  $77.4 \pm 11.5$ ) but also showed no statistical difference ( $P > 0.05$ ). (Table 2)

**Table 1** Demographic data of patients.

Parameters	Good fixation group	Poor fixation group	P-value
Gender (F:M)	3:10	4:21	0.672
Mean age, year (range)	$52.6 \pm 9.5$	$45.9 \pm 12$	0.0884
Preoperative Bohler's angle	$8.8 \pm 8.9$	$11.8 \pm 8$	0.346
Essex-Lopresti classification			
Joint depression type	7	12	1.000
Tongue type	6	13	
Sander classification			
II	7	19	0.270
III	6	6	

**Table 2** Postoperative radiographic parameters and clinical outcomes.

	Good fixation group	Poor fixation group	P-value
Number of cases, n	13	25	
Bohler's angle			
Postoperative	23.7±7.7	23.7±6.6	0.9959
3 months follow up	21.8±8.1	21.5±7.2	0.9235
Decrease	1.9±1.4	2.2±1.7	0.6743
FAAM score	77.4±11.5	84.1±13.5	0.1351

## Discussion

The primary goals in surgical treatment of calcaneal fractures are to restore the height and length of the calcaneus, correct heel varus, restore the normal anatomic width and to reduce the posterior facet congruity<sup>(15)</sup>. The lateral extensile approach has been accepted as the gold standard for open reduction and internal fixation these fractures. However lateral extensile approach has a high rate of wound complication<sup>(16)</sup>. Sinus tarsi approach is increasing in popularity. This approach was founded safe and effective to treat Sander type II,III calcaneal fracture with lower complication rate<sup>(17)</sup>. Sinus tarsi approach provide good exposure, adequate reduction and internal fixation of subtalar joint<sup>(18)</sup>. For fixation options, Both screws and mini-plate systems can applied with sinus tarsi approach<sup>(19)</sup>.

The biomechanical study showed no statistically significant difference between 3.5 mm cortical and 4.0 mm cancellous screw in fixing intraarticular calcaneus fracture<sup>(20)</sup>. According to finite element study on sustentaculum tali screw, the 3.5 mm cortical screw was recommended<sup>(21)</sup>. In Maharat Nakhon Ratchasima hospital, we mainly use sinus tarsi approach with 3.5 mm cortical screws fixation technique due to lower rate of wound complication and lower cost of treatment.

Sustentacular screw is one of the critical procedures that restore congruity of articular surface and improve stability of fixation<sup>(21)</sup>. These procedures need the accurate angle of screw placement and specific intraoperative fluoroscopic view to confirm accurate placement<sup>(7,21)</sup>. Although many techniques were presented to increase accuracy of the sustentaculum screw placement, but intraoperative assessment with 2D fluoroscopy cannot show the definite assessment. In this situation, postoperative 3D-CT scan can help to predict clinical outcome and screw placement<sup>(22)</sup>. The 3D imaging offers the information about entire structure of calcaneus. One study showed the accuracy of sustentaculum screw placements were 21 percent on optimum placement and 39 percent on marginal placement<sup>(12)</sup>. In the present study, the accuracy of sustentaculum screw placement was 34 percent based on postoperative 3D-CT scan.

The surgical restoration of Bohler's angle can improve the outcome and has a predictive value for subtalar joint fusion<sup>(23)</sup>. The decrease of Bohler's

angle may reflect secondary displacement and poor prognostic outcome. Minfei Qiang *et al* studied effect of sustentaculum screw placement with lateral locking plate technique and showed the sustentaculum screw with poor fixation may cause the decrease of Bohler's angle<sup>(12)</sup>. In the present study which uses screw only technique, the decrease of Bohler's angle between two groups of the fixation was not statistically different so the stability of fixation may be not affected by the sustentaculum screw placement. The FAAM scores are similar between these two groups.

The limitations of this study were retrospective study design which selection and information bias can occur. The small number of patients might not differentiate outcome between two groups. Short durations of assessment could not show long term functional outcome. However, this study provides some initial information of sustentaculum screw placement that needs future investigation with prospective study design, larger number of patients and longer duration of clinical outcome assessment.

## Conclusion

Position of the sustentaculum screw do not show statistical difference of the decrease of Bohler's angle and FAAM score in operative treatment of intraarticular calcaneal fracture using screws only technique.

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## Acknowledgments

None.

## Potential conflicts of interest

The authors declare no conflicts of interest.

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ตำแหน่ง *sustentaculum screw* ต่อผลการรักษากระดูกสันเท้าหักแบบเข้าข้อด้วยวิธีการยึดด้วยสกรูเพียงอย่างเดียว

อดิสร จงหมื่นไวย้, พบ

**วัตถุประสงค์:** การใส่ *sustentaculum screw* เป็นขั้นตอนที่มีความสำคัญในการผ่าตัดกระดูกสันเท้าหัก ตำแหน่งที่ไม่แม่นยำอาจทำให้เกิดความไม่มั่นคงของการยึดกระดูกได้ การศึกษานี้มีเป้าหมายเพื่อที่จะประเมินผลของตำแหน่ง *sustentaculum screw* ต่อการลดลงของ *Bohler's angle* และคะแนนการใช้งานของเท้าและข้อเท้า (*FAAM score*)

**วิธีการศึกษา:** ศึกษาแบบย้อนหลังในผู้ป่วยที่เข้ารับการผ่าตัดรักษากระดูกสันเท้าหักด้วยการใช้สกรูเพียงอย่างเดียวผ่าน *sinus tarsi approach* ช่วงระหว่าง มิถุนายน พ.ศ. 2560 ถึง มีนาคม พ.ศ. 2563 ในโรงพยาบาลมหาวิทยาลัยราชสิมา ตำแหน่งของ *sustentaculum screw* ถูกประเมินด้วยภาพถ่ายทางรังสีแบบตัดสามมิติหลังผ่าตัด ตำแหน่งของ *sustentaculum screw* ถูกแบ่งเป็นกลุ่มที่ยึดได้ดี (สกรูสามารถยึดได้กับกระดูกเนื้อที่บของ *sustentaculum tali*) และกลุ่มที่ยึดได้ไม่ดี (สกรูไม่สามารถยึดได้กับกระดูกเนื้อที่บของ *sustentaculum tali*) *Bohler's angle* หลังผ่าตัดและเมื่อนัดมาติดตามการรักษาที่ 6 เดือนถูกนำมาเปรียบเทียบกัน และคะแนนการใช้งานของเท้าและข้อเท้า (*FAAM score*) ถูกนำมาประเมินผลลัพธ์ทางคลินิกที่ 6 เดือน

**ผลการศึกษา:** ผู้ป่วย 38 ราย (หญิง 7 รายและชาย 31 ราย) ที่อายุเฉลี่ย  $48 \pm 11.6$  ได้ถูกนำมาศึกษา อายุของผู้ป่วย, *Bohler's angle* ก่อนผ่าตัดและลักษณะของกระดูกที่หักระหว่างทั้งสองกลุ่มที่ยึด *sustentaculum screw* ไม่มีความแตกต่างกันอย่างมีนัยสำคัญ ภาพถ่ายทางรังสีแบบตัดสามมิติแบ่งกลุ่มได้เป็นกลุ่มยึดได้ดี 13 ราย และยึดได้ไม่ดี 25 ราย การลดลงของ *Bohler's angle* และผลคะแนนการใช้งานของเท้าและข้อเท้า (*FAAM score*) ที่ 6 เดือน ไม่มีความแตกต่างกันทางสถิติระหว่างทั้งสองกลุ่ม ( $P > 0.05$ )

**สรุป:** ตำแหน่งของ *sustentaculum screw* ไม่แสดงความแตกต่างทางสถิติของ *Bohler's angle* ที่ลดลงและคะแนนการใช้งานของเท้าและข้อเท้า (*FAAM score*) ในการผ่าตัดกระดูกสันเท้าหักแบบเข้าข้อโดยวิธีการยึดด้วยสกรูเพียงอย่างเดียว

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