

# Research Paper: Outcomes of Minimally-Invasive Sinus Tarsi Approach for the Treatment of Intra-articular Calcaneal Fracture



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## ABSTRACT

**Background:** Open reduction and internal fixation is the standard surgical treatment of calcaneal fractures. However, it is associated with a high rate of wound problems.

**Objectives:** In this study, we evaluated the clinical and radiologic outcomes, as well as the wound complication rates of sinus tarsi minimally-invasive approach in the treatment of intra-articular calcaneus fracture.

**Methods:** In a retrospective study, 62 patients who were referred with an intra-articular calcaneus fracture and treated with a minimally-invasive sinus tarsi approach were included. The radiographic evaluations included the assessment of Bohler and Gissane angles before and after the surgery, as well as the height and length of the calcaneus. The clinical outcome was assessed with the American Orthopedic Foot and Ankle Society (AOFAS) questionnaire.

**Results:** The Mean±SD age of the patients was 41.8±12.7 years. The Mean±SD follow-up of the patients was 21.3±10 months. After 6 months, in 43 patients (69.3%) both Bohler's and Gissane's angles were significantly improved after the surgery (P=0.003 and P<0.001, respectively). The calcaneus height was significantly improved after the surgery (P=0.009), as well. The Mean±SD AOFAS score of the patients was found 79.6±7. Wound infection was seen in only 1 case (1.6%). Delayed wound healing occurred in 4 cases (6.4%). No other wound complication such as dehiscence and skin necrosis was recorded.

**Conclusion:** Minimally-invasive sinus tarsi approach is an efficacious procedure for the treatment of intra-articular calcaneus fracture with a minimized rate of wound complications.

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## 1. Introduction

**C**alcaneal fractures are common lower limb injuries accounting for nearly 2% of all fractures and 60% of tarsal bone fractures [1, 2]. These fractures generally occur following a high-energy trauma such as falling from a height and could be extra-articular or intra-articular. In up to 75% of cases, the fracture is intra-articular and associated with a high rate of complication and morbidity [2-4]. Since many patients might be unable to return to work for several years, the social and economic impacts of these fractures are also remarkable [4]. Therefore, optimizing the outcome of calcaneal fractures is an orthopedic priority.

Conservative management of calcaneal fractures was more popular in the past. Over time, unsatisfactory results of conservative treatment and its association with severe functional loss and disability led to a shift towards surgical treatment [5-7]. Open Reduction and Internal Fixation (ORIF) is the standard surgical treatment of calcaneal fractures. Even so, the procedure is followed with a high rate of wound problems (up to 43%), skin necrosis (up to 11%), superficial and deep infection (up to 19.7% and 5.6%, respectively), and osteomyelitis (nearly 1%) [8-12]. Therefore, the optimal management of calcaneal fractures has remained controversial so that some surgeons opt for conservative treatment to avoid complications of ORIF surgery [13].

Recently, several minimally-invasive surgeries (MISs), including fixation through mini-incisions, arthroscopically-assisted reduction and fixation, and calcaneoplasty have been developed to reduce the postoperative complications of ORIF surgery and preliminary results of these techniques were satisfactory. However, the current evidence is not enough to support the superiority of any available MIS technique, and thus, further studies are required to reach a consensus in this respect [13].

This study aims at evaluating the clinical, radiographic, and functional outcomes of intra-articular calcaneal fracture in patients who were treated with a mini-incision sinus tarsi approach as one of the most common MIS techniques.

## 2. Methods

This study was approved by the Review Board of our institute, and written informed consent was obtained from the patients to use their medical data for publication. In a retrospective cohort, the patients who were referred to our orthopedic hospital between 2015 and 2018 with

an intra-articular calcaneal fracture and treated with sinus tarsi MIS technique were evaluated for eligibility. The inclusion criteria were the follow-up of at least six months and solitary intra-articular fractures. The exclusion criteria were extra-articular and open fractures, other concomitant foot fractures, preoperative deformity of foot bones, history of pain and limited range of movements in the ankle, any musculoskeletal disorder affecting the normal gait of the patient, and bilateral fractures.

We included all patients who had been treated with sinus tarsi MIS technique during the study period and met the study inclusion criteria (n=62). The demographic characteristics of the patients were extracted from their medical files. Normal plain ankle radiographs were used for the evaluation of the postoperative Bohler and Gissane angles (Figure 1), as well as the basement of length and height of the calcaneus (Figure 2). The preoperative radiographic measures were routinely recorded for all patients in our center. All the radiographic measures were done on the lateral radiographs. The normal Bohler angle was considered 20° to 40° [14]. The normal Gissane angle was regarded as 105° to 135° [15].

### Surgical procedure

Preoperatively, the sinus tarsi location was marked (Figure 3A). After prep and drape in the lateral position and tourniquet application at sinus tarsi, an incision was made along the line, which connects the tip of the lateral malleolus to the base of the fourth metatarsal bone (Figure 3B). Then the peroneal tendons were opened to the lateral malleolus tip, while the sural nerve sheet was preserved. The peroneal tendons were then retracted (Figure 3C). Care was taken not to violate the sheet placed at the posterior aspect of the lateral malleolus to avoid subluxation. Subsequently, the sinus tarsi were shaved, and two pins were inserted, one in the neck of the talus and the other in the body of the calcaneus and opened using a distractor that was designed in our center (Shafa distractor).

In the following, the depressed joint was reduced using 3 or 4 pins, and the angles were checked radiographically (Figure 3D). If the correction of angles was acceptable, the fracture would be fixed with a calcaneus plate in two sizes depending on the dimensions of the calcaneus (Bijan plate, Tehran, Iran) [16] and locking screws (Figure 3E). The plate was placed at least 5 mm away from the articular surface. Before entering the plate, the peroneal tendons were thoroughly separated from the body and posterior tubercle to ease the placement of the plate on the bone. Then, one screw was introduced at the interior calcaneus to the plate. Before locking with a plate,

a bone punch plaque was applied on the lateral wall to prevent the impingement of the tendons and lateral malleolus with the lateral wall. The distractor was opened after locking of lateral screws in the body and posterior tuberosity and assuring of the correction of Bohler and Gissane angles, articular surface, and height of the ankle. In the end, the alignment of calcaneus and foot was checked clinically (Figure 3F) and if acceptable, the tourniquet would be opened, and the skin sutured.

### Postoperative procedures and follow-up

After the operation, an ankle-foot orthosis was applied for two to three months, and the patients underwent 24-48 h antibiotic therapy with first-generation cephalosporins. The wound was inspected 72 h after the surgery, and if no complication was observed, the patient would be discharged. The full weight-bearing was not allowed for two months. The wound was rechecked at weeks 2, 4, 8, and 12. Plain radiographs were obtained and checked at 1, 3, 6, and 12 month(s) after the surgery (Figure 4). The lateral radiograph of the sixth month was used for the assessment of postoperative Bohler and Gissane angle, calcaneal post facet height, and length. The American Orthopedic Foot and Ankle Society (AOFAS) questionnaire

was used for the clinical evaluation of the treatment result in which the clinical outcome of patients ranges from 0 to 100 concerning the three main categories of function (50 scores), pain (40 scores), and alignment (10 scores). A higher AOFAS score is equivalent to a better clinical outcome [17]. The AOFAS was evaluated at the last visit.

### Statistical analysis

SPSS V. 16 for Windows version was used for the statistical evaluation of data. Descriptive data were presented as Mean±SD or number and percentage. The mean angle values before and after the surgery were compared with a paired t test or its nonparametric counterpart (Wilcoxon test). Potential correlations were evaluated with the Pearson correlation coefficient test. A P-value of less than 0.05 was considered significant.

### 3. Results

A total of 62 patients with the Mean±SD age of 41.8±12.7 years (range: 29-53 years) were evaluated in this study. The sample included 59 (95.2%) men and 3 (4.8%) women. The main mechanism of injury was falling that occurred in 93.5% of patients. The average±SD follow-up of the patients was 21.3±10.6 months (range:

**Table 1.** The demographic and clinical characteristics of the patients with calcaneal fracture treated with minimally invasive surgery

Variables		Mean±SD/No. (%)
Age (y)		41.8±12.7
Gender	Male	59 (95.2)
	Female	3 (4.8)
BMI (kg/m <sup>2</sup> )		26.3±4.2
Involved knee	Right	39 (62.9)
	Left	23 (37.1)
Follow-up (mo)		21.3±10.6
Mechanism of injury	Falling	58 (93.5)
	MVA	4 (6.5)

BMI: Body Mass Index; MVA: motor vehicle accident.

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**Table 2.** Comparison of pre- and post-operative characteristics of the calcaneus

Parameters	Preoperative	Postoperative	P	Uninjured Calcaneus
Length (mm)	83.2 (75 to 92)	82.7 (75 to 91)	0.18	82.4 (72 to 93)
Height (mm)	37.1 (26 to 49)	48.2 (41 to 58)	0.009	50.4 (43 to 61)
Bohler Angle (°)	2.93±15.7	25.4±21.8	0.003	20 to 40
Gissane Angle (°)	96.5±23.8	113±8.7	<0.001	105 to 135

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**Figure 1.** Evaluation of Bohler and Gissane angles on lateral ankle radiographs

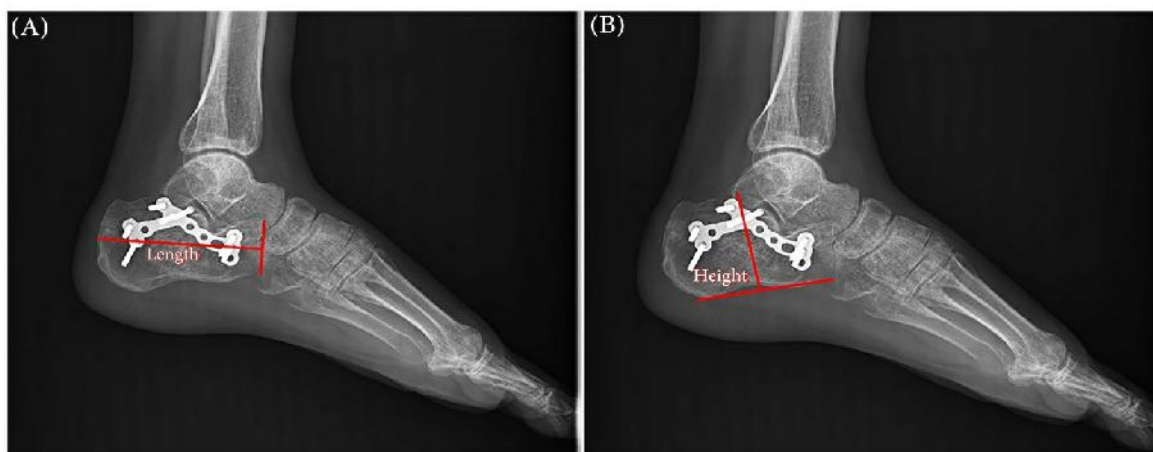
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12-28 months). The clinical and demographic characteristics of the patients are presented in [Table 1](#).

The Mean±SD preoperative Bohler angle was  $2.93 \pm 15.7^\circ$  that changed to  $25.4 \pm 21.8^\circ$  after the surgery. This difference was statistically significant ( $P=0.003$ ). The Mean±SD preoperative Gissane angle was  $96.5 \pm 23.8^\circ$  that changed to  $113 \pm 8.7^\circ$  after the surgery. This difference was statistically significant, as well ( $P<0.001$ ). Preoperative and postoperative Gissane angle, but not Bohler's, were significantly correlated ( $r=0.347$ ,  $P=0.006$  and  $r=0.189$ ,  $P=0.14$ , respectively). Other characteristics of the calcaneus, such as the height and length, significantly improved as well ([Table 2](#)).

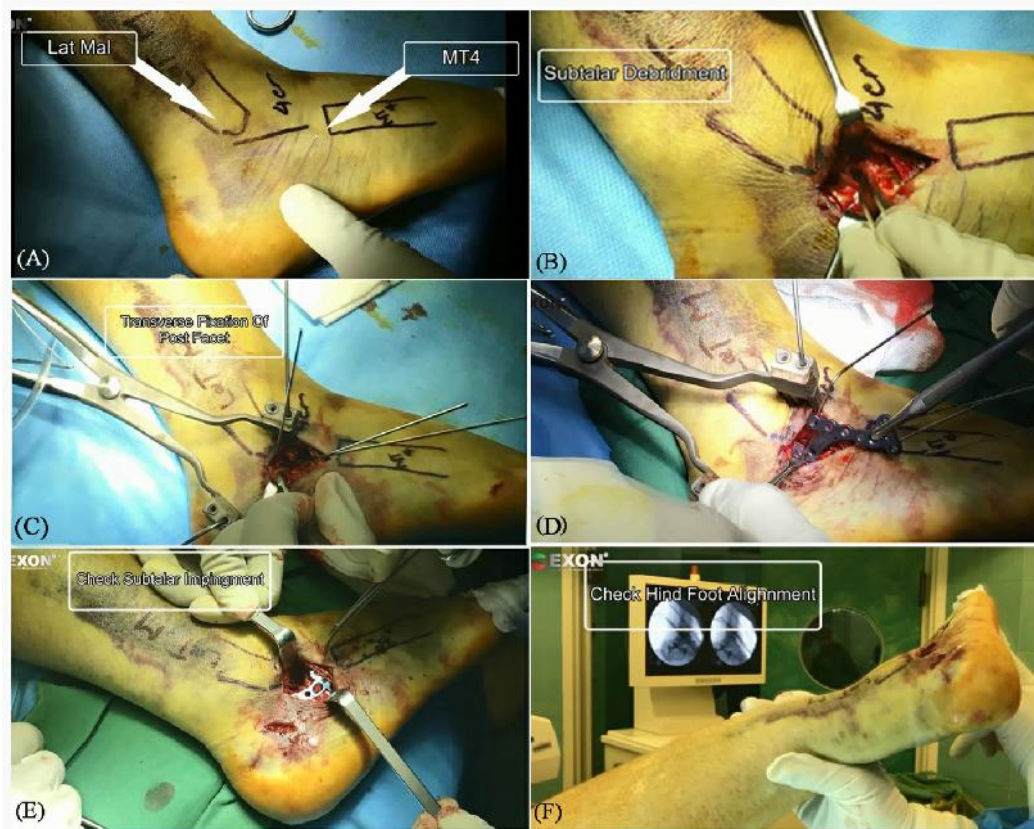
When we compared the pre- and post-operative angles, in 43 patients (69.3%), both Bohler and Gissane angles improved after the surgery. In 17 patients (27.4%), only one of the Bohler or Gissane angles improved. In two cases (3.2%), none of the angles improved after the operation.

The Mean±SD AOFAS score of the patients was  $79.6 \pm 7.1$ , ranging from 74.2 to 85.6. The Mean±SD AOFAS score was  $83.2 \pm 7.6$  in patients in whom both Bohler and Gissane angles improved and it was  $72.5 \pm 6.3$  in patients whose one or no angle improved. This difference was statistically significant ( $P<0.001$ ). AOFAS score was significantly correlated with the Gissane an-



**Figure 2.** Evaluation of the calcaneus length A. and height B. on lateral ankle radiographs

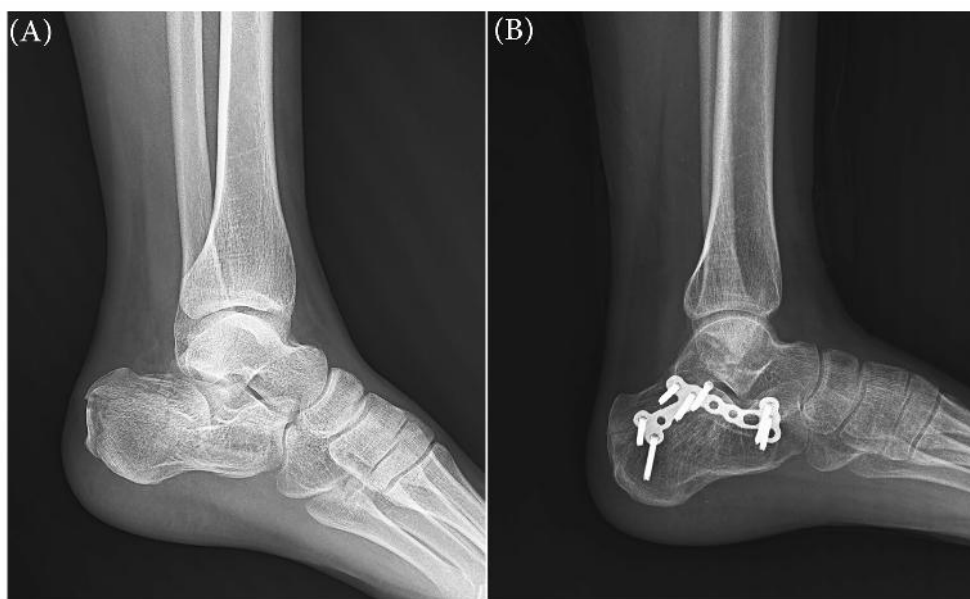
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**Figure 3.** Intraoperative photographs of calcaneus fracture management using MIS technique

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A. Sinus tarsi location was marked preoperatively; B. incision was made along the tip of the lateral malleolus to the base of the fourth metatarsal bone and the peroneal tendons were retracted using a retractor; C. the sinus tarsi was shaved and two pins were inserted using an in-house designed distractor; D and E. the depressed joint was reduced using 3 or 4 pins the fracture was fixed with a plate (Bijan plate) and locking screws; F. The foot and calcaneus alignment was checked clinically and Radiographically.



**Figure 4.** Lateral radiographs showing the A. preoperative and B. three-month postoperative calcaneus fracture treated with minimally-invasive sinus tarsi technique

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gle, but not with the Bohler angle ( $r=0.342$ ,  $P=0.007$  and  $r=0.225$ ,  $P=0.08$ , respectively).

#### Postoperative wound complications

In total, 5 complications (8%) were recorded in this series. Delayed wound healing was seen in 4 cases (6.4%). In these patients, the suture was preserved until the wound got fully sealed and dry. Frequent wound care with mild soap and dressing with or without oral antibiotic therapy was also implicated. Deep infection occurred in one patient (1.6%) and led to the hospitalization of the patient. This infection was managed with intravenous antibiotic injection and just one-time incision and drainage without plate removal. No other wound complication such as skin necrosis was noticed in any of the patients.

#### 4. Discussion

In recent years, MIS techniques have gained considerable popularity in many orthopedic practices [18, 19]. Giannini et al. reviewed the advantage and disadvantages of different MIS techniques in the treatment of calcaneus fracture. Based on their report, the minimally-invasive sinus tarsi approach provides direct visualization of the subtalar joint by allowing the anatomical reduction with minimal hardware implication, thereby reducing wounds complications remarkably [12]. Accordingly, we selected to perform the sinus tarsi approach as the MIS technique of choice in this study.

Based on the results of the present study, Bohler and Gissane angles, as well as the height and length of the calcaneus significantly improved after the treatment of calcaneus fracture with minimally-invasive sinus tarsi approach. The AOFAS score of the patients also reached an acceptable range. Wound complication observed in 5 patients (8%), which included delayed wound healing in 4 cases (6.4%) and deep infection in 1 patient (1.6%).

Amani et al. in a randomized clinical trial compared the outcome of ORIF and mini-incision MIS sinus tarsi technique in the treatment of calcaneus fracture in 40 patients equally allocated into the two groups. The patients were followed up for one year. In both groups, both Bohler and Gissane angles considerably improved after the surgery, although not significantly. Moreover, the AOFAS scores and pain intensity were statistically similar between groups. However, surgical duration was significantly lower in the MIS technique. Four patients in the ORIF group experienced a wound healing complication, while no wound healing complication was recorded in patients

of the MIS group. They concluded that the MIS technique provides similar clinical and radiologic outcomes with a lower complication rate and thus was recommended for the management of calcaneus fracture [20]. Amani et al. only included patients with type II and III fractures based on Sanders classification. In our center, the choice of treatment was based on the loss of normal bone angles as well as the displacement level of bones. Therefore, we included patients regardless of their Sanders type.

Wang et al. also used the minimally-invasive sinus tarsi approach for the treatment of calcaneus fracture in 18 patients (14 Sanders type II and four types III). The radiographic evaluation revealed significant corrections of the Bohler angle, Gissane angle, calcaneal width, length, and height, at the last follow-up. The mean Maryland foot score was 88. Accordingly, the clinical outcome was excellent, good, and fair in 11, 4, and 3 patients, respectively. No wound complication was observed in all fractured feet. They concluded that the minimally-invasive sinus tarsi approach may be safe and effective for the treatment of calcaneal fractures type II and type III [21]. Although we did not classify our patients based on the Sanders classification, our results revealed the favorable radiologic and clinical outcome of the sinus tarsi approach, as well as the acceptable rate of surgical complications.

Xia et al. also evaluated the minimally-invasive sinus tarsi approach for the treatment of 40 displaced intra-articular calcaneus fractures in 38 patients. Type II and type III fractures of Sanders classification were included in this study. Postoperative radiographic evaluation revealed the satisfactory restoration of calcaneal height, width, length, Bohler, and Gissane angles. Excellent, good, and fair clinical results were seen in 32, 6, and 2 patients, respectively. No postoperative complication was found in this series. They concluded that the minimally-invasive sinus tarsi approach is efficacious to attain both satisfactory clinical outcomes and low surgical complication rates [22]. Similar to the study of Xia et al., the current study revealed that a minimally-invasive sinus tarsi approach could result in satisfactory clinical outcomes and an acceptable wound complication rate.

Many other investigations have also demonstrated the efficacy and safety of minimally-invasive sinus tarsi approach in the treatment of displaced intra-articular calcaneus fractures [23-26]. Schepers combined the results of studies that used the sinus tarsi approach in a systematic review. A total of 8 case series reporting the outcome of the sinus tarsi approach in 256 patients with 271 calcaneal fractures were included in this study. An average minor and major wound complications rate of 4.1% and

0.7% were obtained, respectively [27]. The rate of minor and major complications was 6.4% and 1.6%, respectively, in the present study.

Ebraheim et al. reviewed the results of the sinus tarsi approach in 99 patients with 106 intra-articular calcaneal fractures. The patients' composition included type II, III, and IV of Sanders in 71, 25, and 10 patients. Nine (8.5%) cases of postoperative infection were developed in their series comprised 4 superficial wound infection (3.8%), 4 pin tract infection (3.8%), and 1 osteomyelitis (0.9%) [24]. Kikuchi et al. also reviewed the results of the sinus tarsi approach in 20 patients with 22 calcaneal fractures types II, III, and IV. Superficial infection was seen in 3 out of 22 fractures (13.6%). No other wound complication was recorded [28]. It could be concluded that the rate of wound complications depends on the type of fractures so that the rate of wound complication was lower in the studies that included Sanders types II and III [20-22] and higher in the studies that included Sanders types II, III, and IV [24, 28].

The present study was not without limitations. The main weakness of this study was the lack of a control group treated with ORIF so that we could compare the complication rate and clinical outcome of the minimal and extensive surgical approach. Besides, since the patients' treatment was not based on the Sanders type and CT image was not available for many patients, fractures were not typed according to the Sanders classifications. Besides, due to the lack of preoperative calcaneal view radiographs, the improvement of calcaneus width was not assessed in this study. These limitations made it difficult to thoroughly discuss the results in comparison with other investigations. The retrospective design of the study could be regarded as another drawback of this investigation.

## 5. Conclusion

The results of this study reveal that the minimally-invasive sinus tarsi approach is a valuable procedure for the treatment of displaced intra-articular calcaneus fracture. It provides an acceptable radiologic and clinical outcome, as well as a lower rate of wound complications. Further prospective and comparative clinical trials are needed to confirm the results of this study.

## Ethical Considerations

### Compliance with ethical guidelines

This study was approved by the Review Board of our institute (Code: 9411242005)

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## Authors' contributions

Conceptualization, Funding Acquisition, Supervision: Bijan Valiollahi, Hooman Shariatzadeh; Methodology, writing-original draft, investigation: Mehdi Mohammadpour, Mohammadamin Haghbin; Resources: Mehdi Mohammadpour, Mohammadamin Haghbin, Bijan Valiollahi; Writing, review & editing: All authors.

## Conflict of interest

The authors declare no conflict of interest

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