Effect of Tourniquet Application on Postoperative Outcomes in Minimally Invasive Surgery for Intra-articular Calcaneus Fractures

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Research

Keywords: Calcaneal fractures, Creatine Phosphokinase, estimated blood loss, Hospital length of stay, Minimally invasive surgery, Surgical visualization, Tourniquet

Posted Date: March 23rd, 2021

DOI: https://doi.org/10.21203/rs.3.rs-345692/v1

Abstract

Background: Tourniquets are commonly used during foot and ankle surgery to provide a bloodless operative field and for the sake of the surgeon`s comfort, despite the potential risks associated with it. This study was performed to compare postoperative outcomes of tourniquet-assisted to non-tourniquet-assisted operative fixation of calcaneal fractures.

Methods: A total of 131 patients with closed calcaneal fracture who underwent minimally invasive surgery of calcaneal fractures between March 2015 and December 2018 were reviewed retrospectively. Patients for whom a tourniquet was used intraoperatively (n = 62) were compared to those without (n = 69). Operating time and visualization, blood loss, postoperative pain according to visual analogue scale (VAS), the American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot score, and hospital length of stay were recorded for all the patients.

Results: Statistical analysis of the results showed significant differences between tourniquet and non-tourniquet groups in the mean operation time, visibility of the surgical field, mean estimated intraoperative and postoperative blood loss, and mean VAS pain scores 24 H, 48 H, 72 H postoperatively ($P < 0.05$), whereas no significant difference between two groups in the mean Serum CPK levels, post-operative swelling, mean length of stay, AOFAS score, wound and fracture healing time, and the mean time for return to work.

Conclusion: Our study demonstrated that tourniquet application during minimally invasive surgery of calcaneal fractures can significantly shorten the operation time, improve surgical visualization, and reduce intraoperative blood loss. However, adverse events associated with the use of tourniquet include increased postoperative pain, and more amount of postoperative bleeding. Due to higher postoperative pain and more amount of postoperative bleeding, more attention should be paid on the postoperative phase for those who tourniquet was used. The surgeon's decision to use a tourniquet during calcaneal fractures surgery should be carefully considered.

Background

Calcaneal fracture comprises approximately 1–2% of all adult fractures and 60% of tarsal bones fracture. However, about 60–80% of calcaneal fractures are displaced intra-articular fractures [1].Due to the unique shape of displaced intra-articular fractures of the calcaneum, location, and limited soft tissue envelope, treatment is a considerable challenge to the foot and ankle surgeons. Open reduction and internal fixation (ORIF) have become a reality and primary method for treating calcaneal fracture. However, about 15–25% of complication such as wound infection and flap necrosis has been reported [2].

Currently, minimally invasive techniques have been reported to achieve better clinical and radiological outcomes with less wound infections, short hospitalization, and early recovery compared to ORIF techniques [3, 4].

Many factors may affect early weight-bearing and ambulation, and clinical outcomes of the patients after minimally invasive technique of calcaneus fractures. Early weight-bearing may reduce ankle stiffness, bone and muscle atrophy, and help with early recovery activities.

At present, tourniquet is commonly used in a variety of orthopedic surgeries. The purpose of a tourniquet is to prevent blood loss and optimize operative field visualization, thereby improving technical precision and limiting operative duration. However, the use of tourniquet is potentially risky; so, working with tourniquet requires care and expertise. Some studies have shown that tourniquet application is not necessary during minimally invasive such as Arthroscopic ankle surgery [5, 6]. Tourniquet application has potential risks of improper and even proper use during lower limb surgery, including muscle injury, functional weakness and reduced muscle strength, joint stiffness and postoperative swelling [7, 8]. Previous studies have shown that tourniquet is also thought to be associated with an increased postoperative pain, and increased hospital length of stay [9].

Accordingly, the objective of this study was to assess the effect of tourniquet application during minimally invasive technique of intra-articular calcaneal fractures on postoperative outcomes, with the aim of quantifying the value of tourniquet application for visibility and reducing blood loss intraoperatively.

Methods

Study design and period

A retrospective study was conducted at our institution from March 2015 to December 2018 to determine the effect of tourniquet application during minimally invasive technique for intra-articular calcaneal fractures on postoperative outcomes. informed written consent was obtained from all patients for participation in this study.

Study participants and eligibility criteria

Both men and women aged ≥ 20 years at the time of surgery, with closed intra-articular calcaneal fractures and received screw fixation versus plate fixation via the sinus tarsi approach, had at least two years of clinical follow-up from the date of surgery. Exclusion criteria were as follows: patients with open multiple, bilateral fractures, and patients with incomplete medical data. Written informed consent was obtained from all participants. Personal details, age, gender, smoking habit, mechanism of injury, body mass index (BMI), and operative details were recorded accurately on admission.

Sample size and preparation

A total of 131 closed calcaneal fractures patients who underwent minimally invasive procedure were eligible for inclusion. Patients for whom tourniquet was inflated intraoperatively (n=62) were compared to those for whom a tourniquet was not inflated (n=69). If there were swelling of the tissues, surgery was delayed until the swelling of the soft tissue had subsided sufficiently. In all patients, an appropriately sized tourniquet cuff was overlapped around the thigh before anesthesia. Webril bandage or elastic stockinette was always applied under the tourniquet, and an impervious drape was also placed around the cuff to prevent fluids pooling. Patients were blind randomly assigned inflation or not during the operation. When tourniquet was used, the inflation was applied to approximately 100~125 mm Hg over the systolic blood pressure. After surgery, we encourage patients to move and elevate their foot and ankle second day after surgery. Two weeks after surgery, sutures were removed. Then patients were able to exercises and partial weight bearing wearing cast boot or splint 4 to 6 weeks after surgery. We informed them should not weight bear on the injured foot within less than 2 months.

Evaluations

Operation and tourniquet time

The time interval between incisions to completion the dressing was set as the operation time. The tourniquet was inflated just before the incision was made and deflated after skin closure, so the tourniquet time was equal to the operation time. Operating time and tourniquet time were obtained from computer logs and e patient’s medical records.

The operative view

After operation, surgeons were asked to rate visualization of the operative field on 4 points, (1. excellent = no limitation of visualization, procedure not impeded; 2. good = visualization was slightly limited, procedure not impeded; 3. fair = visualization was limited, procedure was slightly impeded; 4. poor = visualization was limited, procedure was markedly impeded).

Intra-operative and Postoperative Blood Loss Estimation

Intraoperative blood loss was measured by the amount of blood in the suction canister minus the amount of irrigation fluid used. Visual estimation of blood volume in surgical gauze also was measured. Postoperatively, wound was typically covered with surgical gauze dressing (45 × 10 cm dry surgical rolled gauze), then compression dressing using cotton padding and ACE elastic bandage. 24 hours after surgery, surgical wound dressing was changed, after that if there were no bleeding, surgical wound dressing was changed every 48 hours. The simple rule of visual estimation of blood volume in surgical

rolled gauze was measured as follows: 45*10 cm dry rolled gauze (Topline ®), 10 ml, 30 ml, and 50 ml of blood saturates about 25%, 50%, and 100% of the surface area, respectively [10].

Hemoglobin Concentration (Hb)

Hemoglobin was measured preoperatively and 48 h postoperatively. The normal HB value in our hospital is between 130 and 175 g/L for men and between 115 and 150 g/L for women.

Serum Creatine Phosphokinase (CPK)

Serum creatine phosphokinase was measured preoperatively, 24 h, 48 h, and 72 h postoperatively. The normal CPK value in our hospital is between 25 and 200 IU / L for men and between 25 and 170 IU / L for women.

Postoperative Pain

Visual Analog Scale (VAS) was used to evaluate postoperative pain. VAS is s a proven subjective measure for acute and chronic pain. The score is recorded by marking a handwritten mark on the 10-cm line, which indicates the continuity between "no pain" and " severe pain". Patients were asked to rate their pain level during the first 24 h, 48 h and 72 h postoperatively.

The amount of swelling of the ankle

To assess the swelling, the circumference of the ankle (around the narrow part of the ankle, usually above the malleoli) was measured preoperatively, 2 and 4 days after surgery [11].

Hospital Length of Stay

Hospital length of stay was defined as the total number of hospital days from the night of surgery to discharge, because most of patients were admitted into the hospital few days prior to the surgery.

American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot Scale

AOFAS scale was used to evaluate objective and functional outcomes. It including 100 points for total: pain (40 points), function (50 points) and alignment (10 points). Scores between 90 and 100 points rated as an excellent, between 80 and 89 points rated as a good, between 70 and 79 rated as a fair, and < 70 points rated as a poor.

Wound healing time

Wound healing refers to the total number of days from the day of surgery to the day that stitches were removed without redness or necrosis.

Time to Union

Postoperatively and during regular follow-up, standard radiograph (X ray radiography and CT scan) were used to assess union time and fracture healing. And time to union was defined by the ability of the patient to walk without pain and confirmed by radiographs showing invisibility of the fracture line and continuity of the cortex.

Return to Work

Return to work was defined by the patient's ability to walk and perform daily activities without pain or crutches.

Statistical Analysis

SPSS (version 23.0; SPSS IBM Corp., Chicago, IL, USA) was used for statistical analysis. Data obeying normal distribution were expressed as (mean ± SD). The difference between two groups was analyzed by using an independent *t*-test. And $P < 0.05$ was considered as statistically significant.

Results

Baseline and Follow-up

Between March 2015 and December 2018, a total of 131 closed calnaneal fracture patients who underwent minimally invasive procedure were included. The patients were followed up for at least 24 months. The tourniquet was used in 62 patients, whereas it was not used in 69 patients. General information of the patients is summarized in Table 1. In the tourniquet group, there were 62 patients, including 46 males and 16 females, with a mean age of 47.0 ± 13.0 years. There were 38 fractures on the right side and 24 fractures on the left side, 12 of patients were smoker and 50 were not. 28 fractures resulted from road traffic accidents and 34 fractures resulted from falls down. We classified all fractures according to the CT classification described by Sanders et al.[12] On CT images, 15 fractures were classified as Sanders type II (3 Sanders IIA, 8 Sanders IIB and 4 Sanders IIC), 27 fractures were classified as Sanders type III (8 Sanders IIIAB, 14 Sanders IIIBC and 5 Sanders IIIAC), and 20 fractures were classified as Sanders IV. None of the 82 feet were type I.

Table 1

Demographic data of the patients[#].

Variable	Tourniquet (n=62)	Non-tourniquet (n=69)
Mean age (year)	47.0 ± 13.0	44.4 ± 12.2
Gender		
Male	46 (74.2)	51 (74.0)
Female	16 (25.8)	18 (26.0)
Feet no		
Right	38 (61.3)	31 (45.0)
Left	24 (38.7)	38 (55.0)
Smoking history		
Yes	12 (19.4)	17 (24.6)
No	50 (80.6)	52 (75.4)
Mechanism of injury		
Traffic injury	28 (45.2)	51 (74.0)
Falling injury	34 (54.8)	18 (26.0)
Type of fracture		
Sanders II	15 (24.2)	41 (59.4)
Sanders III	27 (43.5)	13 (18.8)
Sanders IV	20 (32.3)	15 (21.7)
BMI (kg/m 2)	26.0 ± 2.6	25.3 ± 1.2
-. Abbreviations: BMI, body mass index.		
[#]Values are mean ± standard deviation or no. (%) of patients		

In the non-tourniquet group, there were 69 patients, including 51 males and 18 females, with a mean age of 44.4 ± 12.2 years. There were 31 fractures on the right side and 38 fractures on the left side, 17 of patients were smoker and 52 were not. 51 fractures resulted from road traffic accidents and 18 from falls down. On CT images, 41 fractures were classified as Sanders type II (18 Sanders IIA, 19 Sanders IIB and 4 Sanders IIC), 13 fractures were classified as Sanders type III (4 Sanders IIIAB, 5 Sanders IIIBC and 4 Sanders IIIAC), and 15 fractures were classified as Sanders IV. None of the 89 feet were type I.

Operation time

The mean tourniquet inflation of the tourniquet group was 258.3 ± 9.1 mm Hg. The mean operation time of the tourniquet group was 64.7 ± 3.5 minutes, while that of the non-tourniquet group was 76.0 ± 6.1 minutes. Compared with the non-tourniquet group, the tourniquet group reduced the operation time by 11.3 ± 2.6 minutes. The difference between the two groups was statistically significant ($P < 0.001$) (Table 2).

Table 2
Comparison of operation time, operative view, blood loss, HB, and CPK between two groups[#].

Variable	Tourniquet (n = 62)	Non-tourniquet (n = 69)	*P*-value
Operation time (minutes)	64.7 ± 3.5	76.0 ± 6.1	< 0.001[a]
Operative view			< 0.001[a]
Excellent	56 (90.3)	28 (40.6)	
Good	4 (6.5)	22 (31.8)	
Fair	2 (3.2)	14 (14.5)	
Poor	0 (0.0)	5 (13.1)	
Estimated blood loss (mL)			
Intraoperatively	56.6 ± 33.3	205.0 ± 31.6	< 0.001[a]
Postoperatively	100.0 ± 25.3	38.3 ± 19.8	< 0.001[a]
HB Concentration (g/L)			
Preoperatively	135.3 ± 14.2	135.2 ± 14.1	0.436
48 h postoperatively	134.3 ± 12.7	131.7 ± 10.1	0.487
Serum CPK levels (IU/L)			
Preoperatively	128.0 ± 30.6	126.2 ± 40.0	0.116
24 h postoperatively	136.0 ± 42.0	131.4 ± 40.0	0.148
48 h postoperatively	138.3 ± 40.5	134.3 ± 36.7	0.164
72 h postoperatively	133.0 ± 41.5	124.3 ± 39.8	0.125
-. Abbreviations: HB, Hemoglobin; CPK, Creatine Phosphokinase.			
[#]Values are mean ± standard deviation or no. (%) of patients			
[a] Statistically significant ($P < 0.05$).			

The operative view

The visibility in the tourniquet group (n = 62) was rated excellent in 56 cases, good in 4 cases, and fair in 2 cases. None of the cases was rated poor visibility.

The visibility in the non-tourniquet group (n = 69) was rated excellent in 28 cases, good in 22 cases, fair in 14 cases and poor in 5 cases.

The operative view was statistically significant between two groups ($P < 0.001$). visibility in the tourniquet group was satisfactory (excellent/good) in 60 cases and unsatisfactory (fair/poor) in 2 cases. Visibility in the non-tourniquet group was satisfactory (excellent/good) in 50 cases and unsatisfactory (fair/poor) in 19 cases. The tourniquet required inflation in 9 cases (in which visibility was rated fair/poor) intraoperatively, and accounted for 13–75% of the total operation time, the inflation reason was recorded as bleeding in 4 cases and poor view in 2 cases. Of those, the visibility of 8 (88.9%) cases was improved to at least a good level (Table 2).

Blood Loss Estimation

In the tourniquet group, the mean estimated intraoperative and postoperative blood loss was 56.6 ± 33.0, and 100.0 ± 25.3 mL, respectively, while that of the non-tourniquet group was 205.0 ± 31.6, and 38.3 ± 19.8 mL, respectively. Compared with two groups, intraoperative bleeding was more in the non-tourniquet group by 148.4 ± 5.0 mL, whereas postoperative bleeding was more in tourniquet group by 61.6 ± 3.5 mL. This difference was statistically significant between the two groups ($P < 0.05$) (Table 2).

Hemoglobin Concentration (Hb)

The mean HB level was 135.3 ± 14.2 g/L preoperatively, and 134.3 ± 12.7 g/L 48 h postoperatively, in the tourniquet group. In the non-tourniquet group, the mean HB level was 135.2 ± 14.1 g/L preoperatively, and 131.7 ± 10.1 g/L 48 postoperatively. This difference was not statistically significant between the two groups ($P > 0.05$) (Table 2).

Serum Creatine Phosphokinase (CPK)

The mean serum CPK level was 128.0 ± 30.6 IU/L preoperatively, and 136.0 ± 42.0, 138.3 ± 40.5, 133.0 ± 41.5 IU/L in the first 24 h, 48 h, and 72 h, respectively, postoperatively, in the tourniquet group. In the non-tourniquet group, the mean serum CPK level was 126.2 ± 40.0 IU/L preoperatively, and 131.4 ± 40.0, 134.3 ± 36.7, 124.3 ± 39.8 IU/L in the first 24 h, 48 h, and 72 h, respectively, postoperatively. The mean serum CPK level did not exceed the normal levels at any of the measuring time points. This difference was not statistically significant between the two groups ($P > 0.05$) (Table 2).

Postoperative Pain

In the tourniquet group, the mean VAS scores were 4.3 ± 1.8, 3.1 ± 1.2, and 2.0 ± 0.5 points in the first 24 h, 48 h, and 72 h, respectively, postoperatively. In the non-tourniquet group, the mean VAS scores were 2.1 ± 1.1, 1.6 ± 1.0, and 1.0 ± 0.3 points in the first 24 h, 48 h, and 72 h, respectively, postoperatively. Compared with non-tourniquet groups, the mean VAS scores were higher by 2.2 ± 0.7, 1.5 ± 0.2, and 1.0 ± 0.2 points

in the first 24 h, 48 h, and 72 h, respectively, postoperatively, in the tourniquet group. This difference was statistically significant between the two groups ($P < 0.05$) (Table 3).

Table 3
Comparison of ankle circumference and VAS scores between two groups.

Variable	Tourniquet (n = 62)	Non-tourniquet (n = 69)	*P*-value
VAS scores			
24 hrs. postoperatively	4.3 ± 1.8	2.1 ± 1.1	< 0.001[a]
48 hrs. postoperatively	3.1 ± 1.2	1.6 ± 1.0	< 0.001[a]
72 hrs. postoperatively	2.0 ± 0.5	1.0 ± 0.3	< 0.001[a]
Ankle circumference (cm)			
Preoperatively	21.7 ± 2.6	21.1 ± 2.4	0.343
48 hrs. postoperatively	25.0 ± 2.8	23.1 ± 2.3	0.182
72 hrs. postoperatively	23.2 ± 2.7	22.0 ± 2.4	0.973
-. Abbreviations: VAS, Visual Analogue Scale.			
Values are expressed as mean ± standard deviation.			
[a] Statistically significant ($P < 0.05$).			

The amount of swelling of the ankle

The mean ankle circumferences was 21.7 ± 2.6 cm preoperatively, and 25.0 ± 2.8, 23.2 ± 2.7 cm in the first 48 h and 72 h respectively, postoperatively, in the tourniquet group. In the non-tourniquet group, the mean ankle circumferences were 21.1 ± 2.4 cm preoperatively, and 23.1 ± 2.3, 22.0 ± 2.4 cm in the first 48 h and 72 h respectively, postoperatively. Compared with non-tourniquet groups, the mean ankle circumference was higher by 1.9 ± 0.5, and 1.2 ± 0.3 cm in the first 48h and 72 h, respectively, postoperatively, in the tourniquet group. This difference was not statistically significant between the two groups ($P > 0.05$) (Table 3).

Hospital Length of Stay

The mean length of stay in hospitals was 3.8 ± 1.4 days in the tourniquet group, while that of the non-tourniquet group was 3.1 ± 1.2 days. This difference was not statistically significant between the two groups ($P > .05$) (Table 4).

Table 4
Comparison of AOFAS scores, length of hospital stays, wound healing, time to union, Back to Work and Infection Between Two Groups[#].

Variable	Tourniquet (n = 62)	Non-tourniquet (n = 69)	*P*-value
Length of hospital stay	3.8 ± 1.4	3.7 ± 1.2	0.851
Last follow-up AOFAS (total)	94.0 ± 3.7	93.1 ± 3.0	0.176
Wound healing time (day)	12.3 ± 2.3	12.1 ± 1.6	0.173
Complications	5 (8.1)	2 (2.9)	-
Time to union (week)	11.6 ± 0.8	12.0 ± 1.2	0.984
Back to work (week)	15.2 ± 3.4	15.5 ± 3.7	0.561
-. Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot Scale.			
[#]Values are mean ± standard deviation or no. (%) of patients			

American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot Scale

In the tourniquet group the mean total AOFAS was 94.0 ± 3.7 points, while that of the non-tourniquet group was 93.1 ± 3.0 points at the last follow up. This difference was not statistically significant between the two groups ($P > 0.05$) (Table 4).

Wound healing time

In the tourniquet group the mean wound healing time was 12.3 ± 2.3 days, while that of the non-tourniquet group was 12.1 ± 1.6 days. This difference was not statistically significant between the two groups ($P > 0.05$) (Table 4).

Complications

In the tourniquet group, delayed wound healing was seen in 5 cases, and 2 cases in the non-tourniquet group. Conservative treatment with systemic antibiotic therapy and local wound care were applied for those patients (Table 4).

Time to Union

In the tourniquet group, the mean time to union was 11.6 ± 0.8 weeks, in the non-tourniquet group the mean time to union was 12.1 ± 1.2 weeks as determined by X-ray. This difference was not statistically significant between the two groups ($P > 0.05$) (Table 4).

Return to Work

The mean time for return to work was 15.2 ± 3.4 weeks in the tourniquet group, whereas in the non-tourniquet group the mean time for return to work was 15.5 ± 3.7 weeks. This difference was not

statistically significant between the two groups ($P > 0.05$) (Table 4).

Discussion

Tourniquet is a commonly used in a variety of foot and ankle surgeries in order to improve surgical field visibility, decrease intraoperative blood loss, and reduce operating time. This study aimed to quantify the effect of tourniquet application on postoperative outcomes after minimally invasive surgery of calcaneal fractures. Overall, our study showed that tourniquet application resulted in decreased operating time, improved operative field visibility, and reduced intraoperative blood loss. Besides, the findings of the study showed that tourniquet application was associated with increased postoperative pain, and blood loss in the first 24hr, 48hr, and 72 hr.

To our knowledge, no prior studies have examined the effect of tourniquet use on outcomes in minimally invasive treatment for calcaneal fractures. We believe this is the first article assessing feasibility and visibility of the minimally invasive procedures, so this article adds new information to the published literature.

In this study, we found that the mean operating time was significantly longer in the patients who undergo surgery without tourniquet. This may be due to the care that exerted by the surgeons when staunch the bleeding and to the fact that, partially obstruction of the surgical field without the tourniquet.

We assessed the difficulty of the operation based on the operative field of vision and time. We have found that the visualization was significantly better in the tourniquet group. In the non-tourniquet group, more flushing was required to provide a better view onto the surgical field. However, the visibility improved in 88.9 of cases after tourniquet inflation.

In the patients without tourniquets, the mean amount of estimated postoperative blood loss was significantly lower during the first 24 h. No patients from either group received a blood transfusion. In the without tourniquet group, electrocautery was used to seal off bleeding blood vessels, whereas no homeostasis was used for the tourniquet group, and the tourniquet is deflated only after skin closure. Based on our extensive experience as foot and ankle surgeons; avoiding tourniquet deflation before skin closure has not caused any problems. Interestingly, similar experience was reported by some researcher on their experience with total knee replacement, internal fixation of ankle fractures, and carpal tunnel release [7, 13, 14].

Muscle tissue damage that caused by tourniquet is not well described. The duration of tourniquet use may cause elevated serum CPK levels; this increase may accurse 8 hours following muscle damage. Muscle tissue damage can lead to increased pain postoperatively compared to non-tourniquet group [15]. However, there were no significant differences in the CPK level between tourniquet and non-tourniquet patients during consecutive measurements, and CPK level did not exceed the normal levels at any of the measuring time points.

Patients in the tourniquet group showed significant higher postoperative pain when compared to non-tourniquet group patients. However, our study results showed that the pain was significantly increased 24 h postoperatively after removing the pressure dressing, and then gradually decreased at 48 h, and 72 h, postoperatively, revealed that it is less likely to be a direct result of ischemic edema and hypoxia caused by the tourniquet, but it may be the result of swelling and hematoma. In the non-tourniquet group, ankle swelling was decreased slowly on postoperative days 2 and 3. This may be the reason for the higher postoperative pain in the tourniquet group.

Postoperative pain remains a significant barrier of delay discharging patients, and it has a significant impact on the patient's ability to return to normal activities after discharge [9]. Postoperative analgesia plays a significant role in allowing the patients exercise and restore mobility, promoting recovery while reducing hospital stay [16].

Our finding did not confirm previous studies that the tourniquet application increases postoperative swelling and length of in-hospital stay [7, 9]. Reduced length of stay in hospitals has significant benefits for the hospital, including resource and cost savings. Whilst some factors that prognosticate hospital length of stay have been identified, the direct and indirect interaction between these factors is less clear. The length of stay in a hospital is an important indicator of resource consumption.

The finding of our study showed that tourniquet application did not result in delayed wound healing or return to work and activities. Generally, minimally invasive procedure is associated with less wound complications, early rehabilitation, and good to excellent clinical outcomes [3, 4, 17, 18].

Time to return to work was evaluated in the study of Maffulli et al. [19] which reported an average difference of 7 days between the tourniquet and non-tourniquet group. Further studies are recommended to evaluate the impact of tourniquet use on return to work after calcaneal fracture surgery.

In the tourniquet group, delayed wound healing was seen in 5 patients, and 2 patients in the non-tourniquet group. According to previous studies, patients with increased BMI, Sanders type, smoking, and postoperative hemovacuum drain may at higher risk of infection and delayed wound healing [20–22]. Furthermore, a recent study by Benedick et al. [23] assessed the effect of tourniquet use on wound healing following ankle fracture surgery, demonstrated that the use of a tourniquet did not delay wound healing or increases the incidence of incision complication.

After surgery, it is recommended to apply a compression dressing using ACE elastic bandage as supplementary negative pressure drainage. The flaps are evenly compressed to decrease bleeding and eliminating space enhances the effectiveness of negative pressure.

Critical hypoxia levels where normal cell function is affected usually in patients with higher tourniquet pressure and longer duration of deflation. However, low tourniquet pressure (< 250 mm Hg) may not be risky and tourniquet inflation for 1 to 3 hours as a safe limit for tourniquet time, and if the anticipated time of surgery is more than 2.5 hours, it should be deflate the tourniquet for 10 to 15 minutes and

elevate the leg before re-inflating again [24, 25]. However, three hours is much more than the duration of surgery reported in this study in the presence of a tourniquet. In our study, conservative treatment with systemic antibiotic therapy and local wound care were applied for those with delayed wound healing patients.

Calcaneal fractures are a serious injury and the most common fracture of the tarsal bones that may lead to lifelong problems. Pain in the joints, stiffness and arthritis frequently develop. Sometimes a fracture fails to heal in the right position. The long-term consequences of calcaneal fractures are decreased ankle motion and limping when walking, which are caused by fracture collapse and loss of length in the leg. It may require a revision surgery and long-term or permanent use of an orthotic device or brace to deal with complications.

Open reduction versus plate fixation via the sinus tarsi approach are currently accepted treatments method for calcaneal fractures. The good to excellent clinical and radiological outcomes, with less wound complications and early recovery have been reported in the minimal invasive sinus tarsi approach. Even complex calcaneus fractures can be fully exposed using a minimally invasive sinus tarsi approach to achieve anatomic reduction and stable internal fixation [3, 4, 17, 18].

Bleeding in the surgical field is the most important problem without the use of a tourniquet. Tourniquets are widely used during upper and lower limbs surgery to provide a bloodless field. There is a lot of controversy about the use of a tourniquet, and the possible benefits must be weighed against the potential risks. Minimal bleeding in the surgical field is the main advantage of using a tourniquet during upper and lower limb orthopaedic surgery. Due to improved visibility, it can shorten the operation time and reduce the technical difficulty of the operation.

Our study has some limitation worth noting. Firstly, this is a retrospective study from a single institution. Secondly, the tourniquet was inflated just before the incision was made and deflated after skin closure, so we cannot comment on the tourniquet deflation before skin closure. Further studies are needed to clarify these points.

Conclusions

the results of this study demonstrated that the advantages of tourniquets application during minimally-invasive technique for intra-articular calcaneal fractures are shorten the operation time, optimized visibility of the surgical field, and decreased technical difficulty by minimize intraoperative blood loss. However, adverse events associated with the use of tourniquet include increased postoperative pain, and more amount of postoperative bleeding. Due to higher postoperative pain and more amount of postoperative bleeding, more attention should be paid on the postoperative phase for those who tourniquet was used. The surgeon's decision to use a tourniquet during calcaneal fractures surgery should be carefully considered.

Declarations

Acknowledgments

The authors wish to thank all participants who volunteered to take part in this study.

Authors’ contributions

MWY, conceived this study. HHZ participated in the study design, participants recruitment, data acquisition, analysis, interpretation and drafting of the manuscript. ZRX performed the manual examination of ankle instability. All authors were involved in the preparation and revision of the manuscript and have approved the submitted version.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Availability of data and materials

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Informed consent was obtained from all subjects. This study was approved by institute of our hospital.

Competing interests

All authors declare that there are no personal or commercial relationships related to this work that would lead to a conflict of interest.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests

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