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Original Research

The Use of Cryotherapy for the Prevention of Wound Complications in the Treatment of Calcaneal Fractures

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ABSTRACT

We analyzed the risk factors for skin infection and necrosis after calcaneal fracture surgery and evaluated the effect of cryotherapy in preventing postoperative skin infections and necrosis. We studied 129 calcaneal fracture patients (148 feet) who had undergone open reduction and internal fixation from January 2008 to December 2010. Three groups included were: control (44 patients; 49 feet), preoperative cryotherapy (43 patients; 48 feet), and perioperative cryotherapy (42 patients; 51 feet). The wound infection rate, Maryland foot score, and postoperative visual analog scale (VAS) score were compared. Risk factors for infection were analyzed using multinomial logistic regression. Both cryotherapy groups had lower infection rates, higher Maryland foot scores, lower VAS scores, and shorter hospitalizations than the control group ($p < .05$). The perioperative cryotherapy group had a lower infection rate, higher Maryland foot score, and shorter hospitalization ($p < .05$) but similar VAS score compared with the preoperative cryotherapy group ($p > .05$). Pre- and postoperative cryotherapy, postoperative drainage, surgical timing, smoking index, alcoholism, and suture method were risk factors for postoperative infection and necrosis. The risk of these can be largely reduced by patients not smoking and drinking alcohol and surgeons choosing the appropriate surgical timing, improving the suturing method, and performing postoperative drainage. Perioperative cryotherapy might be an effective method to decrease the postoperative infection rate, shorten the hospital stay, and reduce postoperative pain. Our findings require further validation in well-designed randomized controlled trials.

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A closed calcaneal fracture is a common orthopedic traumatic condition, accounting for 2% of all fractures (1,2). Displaced calcaneal fractures often require open reduction and internal fixation. The blood supply of the rear foot comes from 3 primary arteries: the lateral calcaneal artery, lateral malleolar artery, and lateral tarsal artery (3). Subcutaneous edema and blood effusion frequently occurs after surgery owing to the thin lateral calcaneal tissue and uneven distribution of the surface vessels. Wound infection and necrosis are common short-term complications associated with open reduction and internal fixation of calcaneal fractures (2,4). These can extend the hospital stay, increase the risk of reoperation, and, even, lead to permanent disability. Studies have suggested that postoperative incision infection is associated with several factors, including the anatomic characteristics of the calcaneus, surgical timing, operative duration, and so forth (5,6). Nevertheless, no comprehensive analyses of the risk factors for postoperative wound complications in calcaneal fracture patients have been previously reported. In the present study, we performed a retrospective analysis of 129 patients with 148 operatively treated calcaneal fractures in our hospital from 2008 to 2010 to investigate the association between wound complications and potential risk factors. The potential risk factors included pre- and postoperative cryotherapy, postoperative drainage, surgical timing, operative time, smoking index (SI), alcoholism, bone graft use, suturing method, and fracture type.

Cryotherapy is commonly used for the treatment of an acute soft tissue injury (7,8). We also evaluated the effects of local cryotherapy in the prevention of postoperative skin infection and necrosis. The present study may provide a basis for the prevention of postoperative wound complications and the reduction of foot pain in clinical practice.

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Patients and Methods

The present retrospective study included 129 calcaneal fracture patients who had undergone open reduction and internal fixation in our hospital from January 2008 to December 2010. The exclusion criteria were as follows: concurrent fractures that might cause postoperative chronic pain such as tibial, fibula, metatarsal, and phalangeal fractures; preexisting calcaneal pain, concurrent peripheral nerve injury, including diabetic foot disease and tarsal tunnel syndrome; and concurrent systemic diseases, such as hypertension, coronary atherosclerotic heart disease, and diabetes. Each patient was examined using dual-source computed tomography, and the fracture type was determined according using the Sanders classification (9): type I, nondisplaced fracture (≤2 mm); type II, obvious displacement (≥2 mm), with a fracture line and 2 fragments; type III, 2 fracture lines and 3 fragments; and type IV, comminuted fracture with 3 fracture lines and ≥4 fragments. All the patients provided written informed consent before surgery.

The patients were divided into 3 groups: 44 (49 feet) in the control, 43 (48 feet) in the preoperative cryotherapy, and 42 (51 feet) in the perioperative cryotherapy group. All the surgeries were performed by the same physician group, consisting of a chief surgeon, a deputy chief surgeon, an attending surgeon, and a resident. The major procedure was performed by the chief surgeon. The patient was placed in the supine position, anesthesia was induced, and surgery was performed using the standard extended lateral approach with an L-shaped incision (10). The vertical arm of the incision was placed midway between the fibula and the Achilles tendon, with the horizontal arm in line with the base of the fifth metatarsal. Each arm of the L was approximately 8 cm long. The subperiosteal flap was everted to expose the peroneal tendons and the sural nerve. The lateral soft tissues and calcaneal periosteum were lifted. The fracture was reduced and fixed with a plate. If necessary, autogenous cancellous iliac bone grafting was performed. A suction drainage tube was placed and fixed with a 1-0 suture thread. The skin was carefully closed in layers using a Donati or Allgöwer-Donati approach with multifilament absorbable antibacterial suture (11). The wound was then closed in standard fashion. Patients in the control group did not receive cryotherapy.

The patients in the preoperative and perioperative cryotherapy groups received local cryotherapy using an ice bag wrapped in a cotton towel (size 75 × 33 cm, thickness 3 to 4 mm thick, and weight 100 g). The ice bag was changed every 2 hours for 72 hours after the injury. The injured limb was lifted and treated with a mannitol injection (125 mL intravenous infusion every 8 hours for a total of 3 times daily) to reduce the edema (12). Blisters were aspirated by syringe, and routine disinfection was performed. Surgery was not started until no obvious discharge from the wound was detected. In the perioperative group, local ice therapy was applied immediately after the surgery, and the ice bag was changed every 2 hours for 72 hours. The drainage tube was removed 2 days after the surgery.

Postoperative skin infection was determined using the following criteria: nonhealing wound, persistent bleeding for >2 weeks, hematoma, flap necrosis, or wound dehiscence (13). Wound infection was confirmed by positive bacterial culture. The number of infections in each group was recorded. All infections were treated with antibiotics and/or removal of internal fixation. The mean age, sex ratio, SI, number of alcoholic patients, fracture type, surgical timing, bond grafting, suture method, operative time, length of hospital stay, and follow-up time for each group were also recorded.

Radiographic examination was performed before and immediately after surgery and at the last follow-up visit to measure the Böhler and Gissane angles. At day 3 after surgery, pain was assessed using a visual analog scale (VAS), with excellent defined as 0 to 2 points, good as 3 to 5 points, fair as 6 to 8 points, and poor as >8 points. At the last follow-up visit, foot function was evaluated using the Maryland foot score (14), with excellent defined as 90 to 100 points, good as 75 to 89 points, fair as 50 to 74 points, and poor as <50 points.

All data were analyzed using the SPSS, version 16.0, software (IBM Corp., Armonk, NY). Data are expressed as the mean ± standard deviation. A pairwise comparison was performed using the t test, and differences among the groups were compared using analysis of variance; $p < .05$ was considered statistically significant. The rate was compared using the χ^2 test (2 groups) or Kruskal-Wallis H test (≥3 groups). Based on the findings from previous studies by Yu et al (15) and Zhang et al (16), 10 variables were used for multiple regression analysis. The SI (defined as the number of cigarettes smoked per day multiplied by the years of smoking [≤20, 0; >20 but ≤100, 1; >100 but ≤200, 2; >200 cigarettes/y, 3), alcoholism (defined using the World Health Organization criteria for alcoholism (17) [alcohol level >60 g/day, 1; ≤60 g/day, 0]), fracture type (type I, 0; II, 1; III, 2; IV, 3), pre- and postoperative cryotherapy (no, 0; yes, 1), surgical timing (<7 days, 0; ≥7 but <14 days, 1), bone grafting (no, 0; yes, 1), suture method (Allgöwer-Donati suture, 0; Donati suture, 1), operative time (<90 minutes, 0; ≥90 minutes, 1), and postoperative drainage (no, 0; yes, 1) were chosen as potential risk factors for postoperative skin infection. These were converted into categorical data for multivariate logistic regression analyses. p Values < .05 were considered statistically significant.

Results

The 3 groups had a similar proportion of males and females, mean age, follow-up time, SI, percentage of alcoholism, percentage of bone grafting, surgical timing, and operative time ($p > .05$; Table 1). Of the 129 patients, postoperative infection was confirmed in 27 (29 feet). All infections were treated with antibiotics. Additionally, 1 patient in the control group was treated with antibiotics and internal fixation removal.

A further pairwise comparison showed that both cryotherapy groups had a shorter hospital stay and lower infection rate than the control group ($p < .05$; Table 2). Moreover, the perioperative group had a shorter hospital stay and a lower infection rate than did the preoperative group ($p < .05$).

Radiographic examination was performed before and immediately after surgery and at the last follow-up visit. The results suggested no significant differences in the average Böhler or Gissane angle among all 3 groups at any point ($p < .05$; Table 3). Pain at 3 days after surgery was assessed using a VAS, and foot function was evaluated at the last follow-up visit using the Maryland foot score. Both cryotherapy groups had a higher percentage of excellent/good foot function and a lower percentage of poor foot function compared with the control group ($p < .05$; Table 4). A further pairwise comparison suggested that the difference in the percentage of excellent/good or poor foot function between the 2 cryotherapy groups was not statistically significant ($p > .05$; Table 3). The VAS score for both cryotherapy groups was

Table 1
General information of subjects in the 3 groups

Variable	Control (44 Patients, 49 Feet)	Preoperative Cryotherapy (43 Patients, 48 Feet)	Perioperative Cryotherapy (42 Patients, 51 Feet)	p Value (χ^2)
Sex				.899 (0.213)
Male	33	34	32	
Female	11	9	10	
Age (y)	38.5 ± 3.4	39.3 ± 3.2	37.9 ± 3.4	.156
Follow-up period (mo)				.307
Mean ± SD	52.10 ± 7.2	54.40 ± 8.1	53.70 ± 7.2	
Range	49 to 58	48 to 60	48 to 59	
Mean SI	369.4 ± 14.1	371.9 ± 16.6	365.9 ± 15.3	.199
Alcoholism	4 (9.1)	14 (38.82)	14 (38.82)	.120 (8.848)
Bone graft	14 (28.57)	14 (29.17)	14 (27.45)	.982 (0.037)
Surgical timing (day)	5.3 ± 1.2	5.1 ± 0.5	5.5 ± 0.8	.118
Operation time (min)	81.6 ± 12.4	82.4 ± 13.2	78.9 ± 11.8	.403
Length of hospital stay (day)	14.2 ± 2.1	11.1 ± 1.5	9.2 ± 1.6	.000
Infection (no. of feet)	14 (28.57)	9 (18.75)	4 (7.84)	.027 (7.211)

Data presented as n, mean ± SD, or n (%).
Abbreviations: SD, standard deviation; SI, smoking index.