

Comparative Study of Internal Fixation for Displaced Closed Fracture of Medial Malleolus Using Malleolar Screw Versus Tension-band Wiring

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Abstract

In a prospective, randomized trial of 40 patients with displaced closed fracture of medial malleolus at Al-Sader, Al-Hakeem, Al-Manathera & private hospitals in Najaf from March 2005 to March 2008, we compared two methods of internal fixation namely malleolar screw and tension-band wiring.

The patients were then allocated to two treatment groups (20 patients in each group). The populations of the groups were similar in age (median 37 years), sex, fracture type (Danis-Weber type B and C), and aetiology (twisting, fall or motor vehicle accident). The patients were evaluated clinically, radiologically, and functionally with follow-up for average of one year.

Radiological union took place in the group treated with tension-band (mean time 9.4 weeks) earlier than those treated with malleolar screw (mean time 11.8 weeks) ($p=0.03$). Excellent and good results were achieved in 80% with malleolar screw fixation and in 90% with tension-band wiring ($p=0.049$). Although better range of motion was noticed in the group treated with malleolar screw, it did not reach significance level ($p=0.628$).

The preliminary results of the current study suggest that tension-band wiring may be more valid option than malleolar screw for internal fixation of medial malleolar fractures.

الخلاصة

في دراسة مستقبلية عشوائية لأربعين حالة كسر متحرك و مغلق لعظم الكعب الإنسي في مستشفيات: الصدر التعليمي، الحكيم، المناذر العام و المستشفيات الأهلية في محافظة النجف من آذار 2005 إلى آذار 2008 قمنا بمقارنة طريقتين للثبوت الداخلي باستخدام البرغي الكعبي وأسلاك الربط التوتيرية.

تم تقسيم المرضى إلى مجموعتين، في كل مجموعة عشرين مريض. كانت المجموعتان متشابهتين في العمر (المتوسط 37 سنة)، الجنس، نوع الكسر (دنس-ويبر نوع B و C) و سبب الكسر (التواء، سقوط، أو حادث سير). تم تقييم المرضى سريريا و وظيفيا و بواسطة الأشعة. كما تمت متابعة الحالات لحوالي سنة بعد العملية.

كان الإلتئام الشعاعي للكسر في المجموعة التي تمت معالجتها بواسطة أسلاك الربط التوتيرية (متوسط الوقت 9.4 أسابيع) أبكر من المجموعة التي تمت معالجتها بواسطة البرغي الكعبي (متوسط الوقت 11.8 أسابيع)، ($p=0.03$).

كانت نسبة النتائج الممتازة والجيدة التي تم الحصول عليها في مجموعة البرغي الكعبي هي 80 % أما في مجموعة أسلاك الربط التوتيرية فكانت 90 % ($p=0.49$).

على الرغم من ملاحظة مدى أفضل للحركة في المجموعة التي تمت معالجتها بواسطة البرغي الكعبي إلا إنها لم تصل إلى درجة الأهمية ($p=0.628$).

إن النتائج الأولية لهذه الدراسة تشير إلى إن أسلاك الربط التوتيرية قد تكون الخيار الأفضل من البرغي الكعبي في الثبوت الداخلي لكسر عظم الكعب الإنسي.

Introduction

The ankle is a close-fitting hinge of which the two parts interlock like a mortise (the box formed by the distal ends of the tibia and fibula) and tenon (the upwards projecting talus)⁽¹⁾.

Stability of the ankle, which is paramount to function in weight bearing, is achieved through an interaction between architecture, capsuloligamentous support and muscular control^(1,2,3).

Medial complex injuries typically occur from eversion and abduction forces. The medial complex consists of the medial malleolus, the medial facet of the talus, and the superficial and deep components of the deltoid ligament. Eversion of the ankle causes injury to the superficial deltoid ligaments and, if sufficient, the deep deltoid ligament. With continuation of these forces, impaction of the distal lateral malleolus occurs, resulting either in rupture of the syndesmosis or in transverse fracture of the distal fibula^(4,5).

The ankle mortise forms a ring, in which three bones are joined by connecting ligaments. Since these ligaments have minimal capacity for stretch, the mortise is functionally a rigid ring, which, for displacement, requires a break in two places. Thus, a displaced fracture of only one malleolus indicates associated ligamentous injury, usually involving either the deltoid or the syndesmotic ligaments, or both^(6,7).

Every eccentrically loaded bone is subjected to bending stresses. This results in a typical distribution of stresses with tension on the convex and compression on the concave side of bone. In order to restore the load-bearing capacity of an eccentrically loaded fracture bone, the tensile forces have to be absorbed by a tension band (wire, plate) and the bone itself has to be able to withstand axial compression^(1,8).

The methods essentially involves placing a wire loop dorsal to the midaxis of the eccentrically loaded fractured bone, thereby converting the destructive and shear forces tending to separate the fragments into compressive forces across the fracture site. This tension band will exert a force equal in magnitude but opposite in direction to the bending force^(1,9,10). The tension-band wire results in dynamic compression; the two Kirschner wires are used to act as an internal splint neutralizing rotational and angular displacement forces. The compressive forces promote early fracture healing. This stable fixation also allows early mobilization and rehabilitation^(11,12,13).

Patients and Methods

Patients: From March 2005 to March 2008 at Al-Sader, Al-Hakeem, Al-Manthera & private hospitals in Najaf, we randomized 40 patients with displaced closed fractures of medial malleolus treated by open reduction and internal fixation with either malleolar screw or with tension-band wiring. They were then allocated to one of two treatment groups:

Group1 (20 patients) had malleolar screw fixation.

Group2 (20 patients) had tension-band wiring.

The populations were similar in age (median 37 years), sex, fracture type (Weber type B and C), and aetiology (twisting, fall, or motor vehicle accident) [Table 1].

The fractures were classified according to the Danis-Weber classification. We exclude those with vertical fractures of medial malleolus because these fractures usually require horizontally directed screws and difficult to be fixed internally by tension-band wiring.

Table 1: Details of 40 patients with medial malleolar fractures

	Group1 (malleolar screw)	Group2 (tension- band)
Median age in years	37 (24-50)	37 (21-53)
Male: female	8:12	8:12
Right: left	15:5	14:6
Weber B:Weber C	14:6	14:6
Causes of the fracture		
Twisting	16	15
Fall	2	3
Motor cycle accident	2	2

Methods:

Preoperative planning: Preoperative evaluation includes assessment of general health and a thorough assessment of neurovascular status of the lower extremity. Radiographic evaluation includes anteroposterior, mortise, and lateral views of the ankle. The surgery was performed before the ankle swells up or when the swelling subsided, which was usually after 10 to 15 days of elevation.

Surgical Technique: All the patients in this study were operated upon under general anesthesia. The patient was positioned supine and an Esmarch or a pneumatic tourniquet was applied to the mid thigh. After routine skin preparation and draping, we made an anteromedial incision that began approximately 2 cm proximal to the fracture line, extended distally and slightly posteriorly, and ended approximately 2 cm distal to the tip of the medial malleolus .We prefer this incision for two reasons: first, the tibialis posterior tendon and its sheath are less likely to be damaged, and second, the surgeon is able to see the articular surfaces, especially the anteromedial aspect of the joint, which permits accurate alignment of the fracture.

Handling the skin with care, and reflecting the flap intact with its underlying subcutaneous tissue. The blood supply to the skin of this area is poor, and careful handling is necessary to prevent skin sloughing. We protect the great saphenous vein and its accompanying nerve.

A small fold of periosteum commonly is interposed between the fracture surfaces. We removed this fold from the fracture site with a curette or periosteal elevator, exposing the small serrations of the fracture. We debrided small, loose osseous or chondral fragments; large osteochondral fragments were preserved. With a small bone-holding clamp, the displaced malleolus was brought into normal position and, while holding it there, internally fixed with either malleolar screw or tension-band wiring.

In group1 patients a 3.2-mm hole was drilled while distal fragment was held reduced with a pointed clamp or with two Kirschner wires bent to stay out of way as temporary fixation devices. Length of hole was measured, and a malleolar screw was inserted without tapping. Kirschner wires were removed after screw is tightened. In two cases the fragments were large and tend to rotate, so we used additional point of fixation (a second screw or Kirschner wire).

In group2 patients the fracture was internally fixed with two 2-mm smooth Kirschner wires drilled perpendicular to the fracture line. The Kirschner wires should be parallel, and their ends were bent at 90° angles. This will eventually prevent the figure-of-eight wire from slipping over the exposed ends of the Kirschner wires. A stainless steel 1.2-mm AO wire was passed through the previously drilled hole and around the bent ends of the Kirschner wires in a figure-of-eight configuration. The wire was then tightened.

We were carefully inspected the interior of the joint, particularly at the superomedial

corner, to make sure that Kirschner wires or the screw had not crossed the articular surfaces.

In conditions where image intensifier was available, we made roentgenograms to verify the position of the screw or the Kirschner wires and any faulty insertion could be avoided. Screen control was used in 3 cases only in our study.

At the end of operation we deflated the tourniquet, obtained haemostasis, and closed the wound with interrupted suture. We avoided tight stitches to prevent necrosis of the skin edges. We applied thick padding and a posterior plaster splint with the ankle in neutral position.

After treatment:

- The ankle is immobilized in a posterior plaster splint with the ankle in neutral position and elevated.
- Postoperative x-ray was taken with anterior, lateral, and mortise views

Follow up:

All the patients were reviewed at 10 to 14 days, six weeks, three months, six months and one year after operation. At each assessment we perform a physical and radiological examination.

After 10 to 14 days the stitches were removed and the wound examined and any complication was reported and treated accordingly. The posterior plaster splint was replaced with a removable splint and range-of-motion exercises are then begun.

Weight-bearing was restricted for 6 weeks,

Evaluation: We evaluate the patients clinically, radiologically, and functionally using a modification of the scoring system proposed by Olerud and Molander (table 2). The scores for each component of this scale were assessed by the use of a questionnaire, in combination with clinical objective

after which the splint discarded and partial weight-bearing started. Full weight-bearing is allowed after 12 weeks.

Table 2: The modified ankle score of Olerud and Molander

Parameter	Score
Pain	
None	25
Minor(weather-dependent)	20
During sports	15
During walking on smooth surfaces	5
Constant and severe	0
Stiffness	
None	10
In the morning	5
constant	0
Swelling	
None	10
Only in the evening	5
constant	0
Stair-climbing	
No problem	10
Impaired	5
Impossible	0
Sports	
Normal	10
Impaired	5
Impossible	0
Supports	
None	10
Tape or wrap	5
Stick or crutch	0
Daily activity & work	
Unchanged level	25
Reduced	20
Change of job	10
Total	100

criteria. The scoring scale has a maximum of 100 points (>91 excellent results, 81-90 good results, 71-80 fair results, <70 poor results). The continuous variables were analysed between groups using Independent sample *t*-test. P value of less than 0.05 was considered statistically significant.

Results

There were no significant differences between the two groups in age (median 37 years), sex, fracture type (Weber type B and C), and aetiology (twisting, fall, or motor vehicle accident) {table 1}.

Review of postoperative radiographs confirmed anatomic reduction with stable fixation in all fourty patients. All the series of radiographs showed normal fracture healing and no patient had malunion, nonunion, or loss of reduction.

The mean time for radiological bone union (indicated by disappearance of fracture line) was 11.8 weeks (ranging from 8 to 18 weeks) in group1 patients and 9.4 weeks (ranging from 6 to 12 weeks) in group2 patients ($p=0.03$). No patients had any sign of fixation failure or kirschner wires migration.

According to the modified ankle scoring system of Olerud and Molander, 2(20%) patients in group1 and 4(40%) patients in group2 were excellent: good in 14(70%) patients in group1 and 14(70%) in group2: fair in 2(20%) patients in group 1 and 2(20%) in group2: poor in 2(20%) patients in group1 and non in group2 patients. Excellent and good results were achieved in 80% in group1 patients and 90% in group2 patients. ($p=0.049$).

Complications

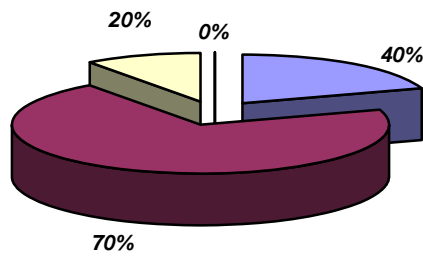
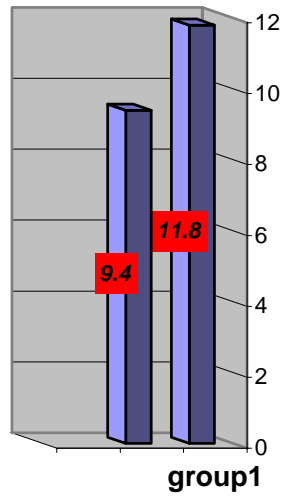
Intraoperative: During reduction of the fracture, use of instruments such as pointed clamps to align and hold the fragments can cause further comminution or crushing of the medial malleolus especially in osteoporotic bone. We developed such complication in one case (2.5%) and it was difficult to fix such fracture using malleolar screws.

We removed the bone clamp and fixed the fracture using two kirschner wires and tension-band wire.

Postoperative:

1. **Skin necrosis.** Necrosis of the skin edges at the site of the operation was recorded in three patients (7.5%), two in group1 and the other in group2 patients. They were treated with meticulous debridement of the necrotic skin and dressing.
2. **Superficial wound infection.** It developed in 4 patients (10%). two in group1 and two in group2. The condition resolved with local wound care, regular dressing and antibiotics.
3. **Delayed union.** two cases (5%) out of 40 cases develops this complication. The patients were female aged 50 years and male aged 43 years; they are treated by malleolar screw (group1 patients).The patients continue to have pain on the medial side of ankle joint after 12 weeks of fixation and the fracture takes around 18 weeks to unite radiologically. During this period we continue in protection of the fracture with splint and full weight-bearing was also delayed.
4. **Limitation of movement.** Clinically the loaded dorsal range of movement was measured at the final follow-up examination by standing the patients on a small elevated box with the knee and hip flexed. Both ankles were measured. 80% of group1 patients compared with 70% of group 2 patients had ankle dorsiflexion greater than 15 degrees ($p=0.628$).

Osteoarthritis was assessed by radiological observation of the joint space, osteophyte formation and ligament calcification. However, we faced two cases of osteoarthritis in this study, the first was a male aged 48 years (group 1) and the other was a lady aged 46 years (group 2).



Discussion

Even though many reports of operative treatment of medial malleolar fractures have been published, comparison of the reports is difficult largely because of lack of uniformity in the subject material and in the criteria to assess the results.

According to the modified ankle scoring system of Olerud and Molander⁽¹⁴⁾, the current study showed that excellent and good results were achieved in 80% in group1 patients (treated with malleolar screws) and 90% in group2 patients (treated with tension-band wiring)(the difference was significant $p=0.049$). This agrees with the results of Sang-Hanko and Young-Junpark who were achieved excellent and good results in about 78% of cases treated with malleolar screws and 89% of cases treated with tension-band wiring^(15,16).

In this study the mean time for radiological bone union was 11.8 weeks (ranging from 8 to 18 weeks) for group1 patients and 9.4 weeks (ranging from 6 to 12 weeks) for group2 patients(significant difference $p=0.03$). This is similar to SK.Nurul et al. study that was reported a mean time of 12 weeks for malleolar screws and 9 weeks for tension-band wiring⁽¹⁷⁾.

We had experienced two cases of delayed union (5%) out of 40 cases of the study and no non-union developed. The patients were female aged 50 years and male aged 43 years treated with malleolar screw fixation and the fracture took around 18 weeks to unite. This result slightly differs from the results of S K. Nuru who achieved 100% union rate in both groups without any case of delayed union^(17,18,19). Authors reported loss of reduction with the use of tension-band technique as a result of K. wires become loosened and migrate proximally⁽²⁰⁾. On the other hand many authors did not agree with the frequency of this complication and reported that with the proper surgical techniques, wire migration was not a problem^(21,22). In this study we did not see any wire migration or loss of reduction.

Tension-band fixation of the medial malleolar fractures has been described or referred to previously by many authors^(23,24,25). Ostrum and Litski recently demonstrated the biomechanic advantages of the tension-band over other fixation techniques for medial malleolus⁽²²⁾. When resisting pronation forces and applying compression force tension-band were four times stronger than malleolar screw⁽²⁶⁾. This might explain the faster union rate we were achieved in group2 patients (mean of 9.4 weeks) as compared with group1 patients (mean of 11.8 weeks).

Rovinsky in his study showed that the tension-band is more technically advantageous over other types of fixation for fixation of small fragment fracture of medial malleolus and is not recommended for the fixation of vertical fracture^(27,28). We agree with these results as in our study we fixed few vertical fractures with horizontally directed malleolar screws but we excluded them from the comparison groups.

Screw fixation alone may provide poor stability against torsional forces^(29,30). This may require an additional point of fixation, which may be a second screw or a Kirschner wire.

Dr. Jones in his study disagrees with these results and showed that single screw fixation had similar results to double screw fixation⁽³¹⁾. In the current study we use additional point of fixation (second screw and K.wire) in two cases in which the fragment was large and tend to rotate.

Limitation of movements and swelling of the ankle are usually the result of neglect in treatment of soft tissue. Although better range of motion was noticed in group1 patients (80%) as compared with group2 (70%), it did not reach significance ($p=0.628$). This could be attributed to wide soft tissue dissection that was needed with the use of tension-band. These results may show similarity with the results of SK.Nurul who reported in his study that the group treated with malleolar screw showed better range of motion⁽¹⁷⁾.

Conclusions

1. The preliminary results of the current study suggest that tension-band wiring may be more valid option for internal fixation of medial malleolar fractures
2. The tension-band wiring is more technically advantageous for small fragment fixation of medial malleolar fractures.
3. The tension-band wiring may be more available and its usage could translate into over all cost saving when applied to the large number of ankle fractures treated surgically in our country.
4. Screw fixation alone may provide poor stability against torsional forces and may require an additional point of fixation which may be a second screw or a Kirschner wire.
5. The faster radiological union which was achieved with the use of tension-band wiring as compared with malleolar screw could be added to the over all advantages of using this technique.
6. During surgical fixation of medial malleolar fractures excessive pressure with bone clamps to hold the fracture reduction should be avoided to prevent crushing of the fragment particularly if the bone is osteoporotic; the fracture reduction instead can hold temporarily with k.wires.
7. Careful and meticulous soft tissue handling is important for prevention of postoperative wound complications, delayed union and joint stiffness.

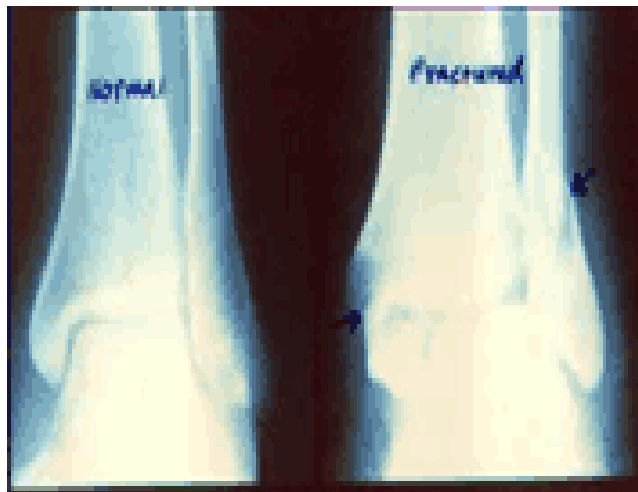


Figure 3: X-ray comparing normal and broken ankles

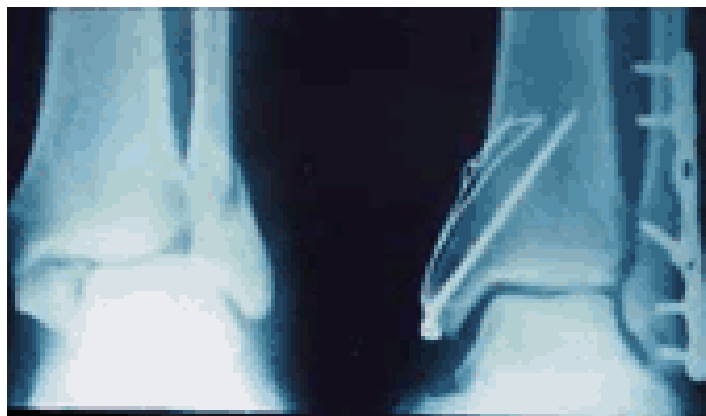


Figure 4: X-rays comparing broken ankle before and after the operation

Preoperative X-rays



Anteroposterior view



Lateral view



Postoperative x-ray

Figure 5: pre-and postoperative x-ray of patient in group1 treated with malleolar screw

Preoperative x-ray



Anteroposterior view



Lateral view

Postoperative x-rays



2 weeks postoperatively



12 weeks postoperatively

Figure 6: pre-and postoperative x-rays of patient in group 2 treated with tension-band wiring

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