Acute management of complex tibial pilon fractures (AO/OTA 43-C)

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Background

In pilon fracture management, careful soft tissue handling is as relevant as the treatment of the bony injury itself. It is crucial to spare the extraosseous vessels during surgery as best as possible. Minimally invasive plate osteosynthesis has attracted great interest in the management of distal tibia fractures and can be used as an alternative to staged approach.

Patients and methods

From January 2009 to December 2013, 32 pilon fractures (AO/OTA 43-C) in 30 patients were treated by acute minimally invasive plate osteosynthesis with distal tibia anatomical locked plates within an average 1.3 days of injury. The mean follow-up time was 30.8 months (24–48 months). Immediate postoperative reduction was assessed, and rating of the symptoms and functional abilities of each patient was done according to American Orthopaedic Foot and Ankle Society ankle-hind foot score.

Results

Satisfactory immediate postoperative radiograph articular reduction was achieved in 90.9% (n=29) ankles. There is no statistically significant difference ($P>0.05$) between immediate postoperative reduction and reduction at the final follow-up. Bony union was achieved in all cases after an average of 4.6 months (3–8 months). The mean American Orthopaedic Foot and Ankle Society ankle-hind foot score at final follow-up was 79. Excellent clinical result was achieved in 21 (65.6%) ankles, good in nine (28.1%) ankles, and poor in two (6.3%) ankles. Complications include one deep infection and two ankle arthrodesis.

Conclusions

Acute minimally invasive approach combined with locking plates for the treatment of complex pilon fractures decreases complications associated with disruption of the soft tissue envelope and associated osseous complications and allows quicker return to function.

Level of evidence: Level IV, case series.

Keywords:

acute management, distal tibia fractures, minimally invasive plate osteosynthesis, pilon fractures type 43C, surgical treatment

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Introduction

Preservation of the soft tissue is of particular importance in the care of pilon fractures. Improper soft tissue management is attributed to high rates of nonunion, wound dehiscence, and fixation failures [1–4].

Traditional open reduction internal fixation (ORIF) of pilon fractures allows for direct visualization of the fracture but is criticized for the large exposure and periosteal stripping. As a result, this approach was blamed for high nonunion rates as well as failure of the soft tissue to accommodate implants [3].

External fixation was also used but has not demonstrated much advantage to internal fixation. External fixation has a higher incidence of malunion and has inherent risks for pin-tract infections [5].

The ‘two-stage’ technique combines the benefits of both external and internal fixation and is thought to limit soft tissue complications by allowing soft tissue recovery time before the introduction of internal fixation [6].

Although such staged treatment has its benefits, tibial pilon fractures may be adversely affected by delayed treatment. Delaying the definitive articular fixation based on the associated soft tissue swelling allows for hematoma organization within this fracture lines. Attempts to reduce this fracture components during definitive fixation of the distal tibial articular surface often proves difficult or impossible, owing to organized clot, other soft tissue, and/or immature callus that may preclude an anatomic reduction. At this point, increased dissection and stripping may be required to clean the fracture to obtain an optimal reduction of the fracture [7].

With the advent of locking plate technology, surgeons have successfully managed a variety of fractures through smaller incisions to introduce the plate: the percutaneous approach. Unlike traditional plating methods, locking plates do not rely on frictional forces between the plate/bone interface to achieve compression and stability. This allows for less damage to the periosteal blood supply, which may theoretically decrease the incidence of delayed or nonunion, soft tissue complications, and possibly secondary loss of fixation [8].

The purpose of this study is to analyze the clinical and radiological results of acute management of complex tibial pilon fractures (AO/OTA 43-C) using minimally invasive plate osteosynthesis (MIPO) with distal tibia anatomical locked plates, with emphasis on immediate postoperative reduction and soft tissue-related complications. We also provide some guidelines to facilitate the operative technique.

Patients and methods

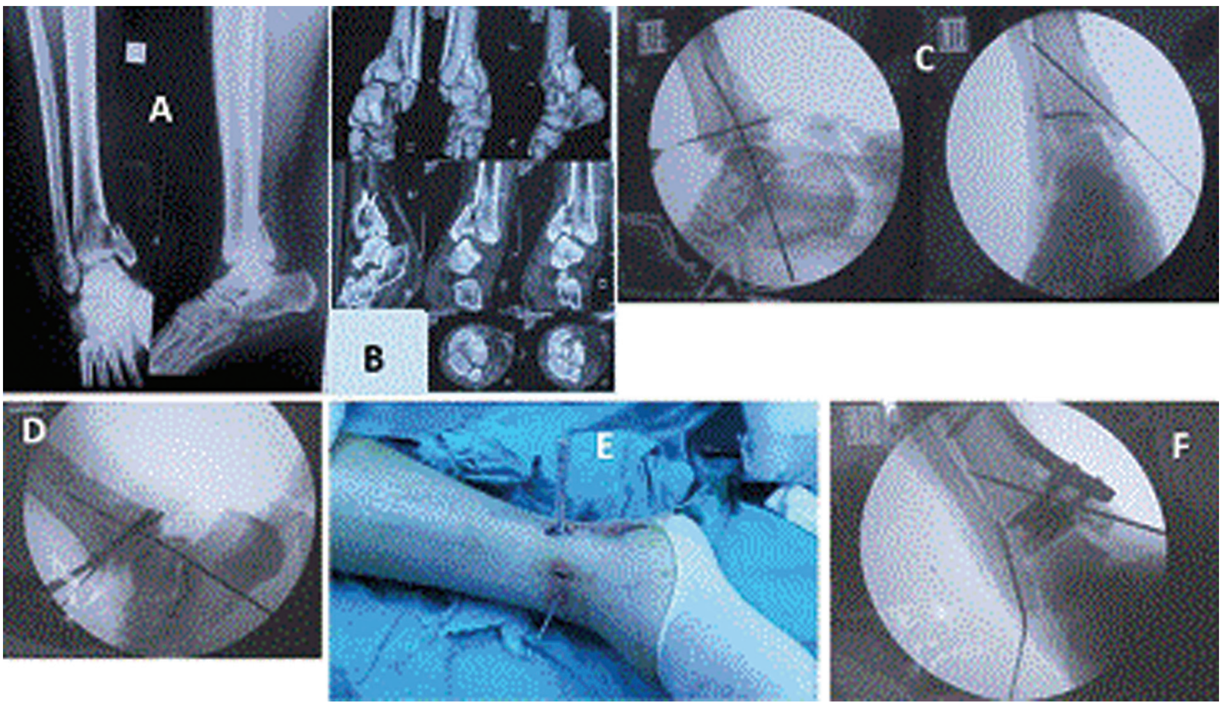
From January 2009 to December 2013, 32 pilon fractures (AO/OTA 43-C) in 30 patients were treated by acute MIPO with distal tibia anatomical locked plates within 1.3 days of injury. All pilon fractures (fractures within 5 cm of the ankle) were identified using standard radiographs obtained in the emergency department (Fig. 1a). Patients with compartment syndrome, vascular injury, or soft tissue injury Tscherne grade III were excluded.

All fractures were evaluated with computed tomography scanning to assist in the preoperative planning of these injuries (Fig. 1b). The soft tissue injury was evaluated according to Tscherne classification [9]. Open fractures were classified by the system of Gustilo and Anderson [10]. Fracture patterns were classified using the AO/OTA Classification [11].

Surgical technique

A tourniquet was applied to the proximal thigh with the patient in the supine position under spinal anesthesia on a radiolucent table. Tibial length, rotation, and distal tibia articular surface alignment are restored indirectly by manual traction. Percutaneous K wires are applied to stabilize reduction: anteroposterior wire to maintain

Figure 1



Surgical technique. (a) Anteroposterior (AP) and lateral radiograph of a 28-year-old male patient who sustained open right ankle pilon fracture in a road traffic accident. (b) Computed tomography scan showing AO/OTA 43-C3 pilon fracture. (c) AP and lateral intraoperative radiographs after fracture reduction by manual traction followed by application of anteroposterior K-wire and another wire from medial maleollus to maintain reduction. (d) AP lag screws. (e) Intraoperative photograph: the proper plate is inserted supraperiosteally through the distal skin incision. (f) Intraoperative radiograph demonstrates excellent reduction.

reduction in lateral view, proximally directed wire from medial maleollus to maintain alignment in anteroposterior view, and sometimes third wire from lateral to medial if there is displaced lateral fragment (Fig. 1c). Once the articular surface has been properly reduced, independent 4.0-mm partially threaded cancellous screws with washers should be used to lag the fragments together. Ideally, the anterior articular fragments should be lagged into the posterior fragment (Fig. 1d). The proper plate length was determined. A plate long enough to provide 3–4 holes proximal to the most proximal extent of the fracture was selected. Medial incision 2–3 cm over the distal fragment is done; depressed articular fragments (central articular fragment or 'die-punch' fragment) are reduced by small periosteal elevator, followed by proximal tunneling with a blunt instrument (usually by longer plate). The plate is then directed supraperiosteally across the metaphyseal fracture (Fig. 1e). Proximally, above the fracture zone, it is important that the plate be centered on the tibia; sometimes proximal 2-cm incision was needed to centralize the plate. Proximally, the plate is fixated first with a single nonlocking screw via a stab incision (reduction screw). Periarticular screws are then placed through the incision, and stab incisions are created for percutaneous placement of diaphyseal locking screws. Rafting screws through the plate were applied to support depressed articular fragments. Medial malleolar fragments may be stabilized percutaneously using 4.0-mm cancellous partially threaded screws.

In cases associated with fractured fibula, usually we did not fix it. Indirect reduction of the fibula is considered an indicator of proper tibial plafond fracture reduction. Cases that showed talar tilt with stress varus, the fibula was fixed by percutaneous K wire (Fig. 1f).

The tourniquet is released, and hemostasis is obtained and the wound closed in layers. Bulky dressing and crepe bandage is applied.

Aftercare

Stitches are removed after 2 weeks. Weight bearing was restricted in all cases for 12 weeks to obtain union of the articular fragments. Early range of motion from second postoperative day is allowed, depending on the degree of comminution and stability of the fixation.

Follow-up program

The mean follow-up time was 30.8 months (24–48 months).

Patients were followed up at regular intervals for clinical and radiological evaluation. Patients were examined every 6 weeks in the first 3 months and then every 3 months. After 1 year, the evaluation was done every 6 months.

Radiographs were then graded, and an overall assessment of the reduction was calculated using the criteria of Ovadia and Beak's [12] and subsequently modified by Teeny and Wiss [4]. Satisfactory reduction had score ranged from 9 to 12 points.

The radiographs obtained at the final follow-up were reviewed for an assessment of union, loss of reduction or fixation, and development of malunion or nonunion.

Ankle arthritis was diagnosed by painful restriction of all movements with or without crepitus with radiological evidence of reduced joint space.

Clinical evaluation includes assessment of pain grade, range of ankle motion, ankle alignment, and return to work and sports. At the last follow-up, rating of the symptoms and functional abilities of each patient was done according to American Orthopaedic Foot and Ankle Society ankle-hind foot score (AOFAS score) [13].

SPSS 10.0 statistical software (SPSS Inc., Chicago, Illinois, USA) was used to analyze the data. A χ^2-test and Student's t-test were used. P values below 0.05 were considered significant.

Results

Patient demographic data are shown in Table 1.

Time to surgery

All cases were managed in the first 48 h after injury, except for two cases associated with spine fracture that were fixed first, were delayed to 5 days.

Radiological evaluation

Immediate postoperative radiograph of articular reduction was obtained. Satisfactory reduction was achieved in 90.9% (n=29) ankles (Table 2, Fig. 1f).

Loss of reduction at final follow-up

Minimal displacement (<2 mm) of articular fragment occurred in two ankles at final follow-up radiograph, which does not affect the final functional outcome (Fig. 2). There is no statistically significant difference (P>0.05) between immediate postoperative reduction and reduction at the final follow-up.

Table 1 Patient demographic data

Patient number	30
Mean age (years)	38.6 (20–70)
Sex	
Men	24
Women	6
Side	
Right	18
Left	10
Bilateral	2
Mechanism of injury	
Road traffic accident	15
Fall from height	13
Pedestrian versus automobile	2
AO/OTA classification [*n* (%)]	
43-C1	8 (28.6)
43-C2	10 (33.3)
43-C3	12 (38.1)
Closed fracture	
Tscherne 0	5
Tscherne 1	12
Tscherne 2	10
Tscherne 3	0
Open fracture	
Gustilo I	3 (tibia)
Gustilo II	1 (fibula)
Gustilo IIIc	1 (tibia)
Associated injury	
Facture fibula	10
Fracture spine	2
Contralateral ankle fracture	2
Time to surgery (days)	0–5 (mean: 1.3)

Table 2 Immediate postoperative radiograph reduction evaluation

Reduction grade	*n*=42
Anatomic	21
Good	8
Fair	1
Poor	2

Radiological union

Bony union was achieved in all cases after an average of 4.6 months (3–8 months) as determined by conventional radiographs.

Delayed union

In four (12.5%) ankles, a later autologous iliac bone graft was performed for delayed union at a mean of 15 weeks (range: 12–20 weeks) after fixation. No cases had primary bone graft.

Clinical evaluation

Pain

Pain was classified into four grades: no pain (grade 1), mild, occasional (grade 2), moderate, daily (grade 3), and severe, usually present even at rest (grade 4).

Twenty-one ankles had no pain, grade 2 pain occurred in nine ankles, and severe type 4 pain in two ankles.

The range of ankle motion

The range of ankle motion was measured with a goniometer. In comparison with the contralateral side, it was used as an objective method for evaluation of the functional result.

In 81.2% (*n*=26) of the ankles, there is normal or mild range restriction (>30°), and in 12.5% (*n*=4) of ankles, there is moderate range of restriction (15–29°). Two ankles (6.3%) had severe limitation (<15°).

Total motion arc averaged was 43° (range: 10–70°). Maximum dorsiflexion averaged was 10° (range: 0–20°), and plantar flexion averaged was 35° (range: 10–50°).

Ankle alignment

Malalignment was reported in three ankles: two varus (5 and 10°) and one valgus (5°). Regarding return to work and sports, 27 (84.4%) patients resumed their former employment, 3 (9.3%) had to change their profession because of pain, two (6.3%) became unemployed, and 20 (62.5%) patients took up their former sporting activities.

American Orthopaedic Foot and Ankle Society ankle-hind foot score

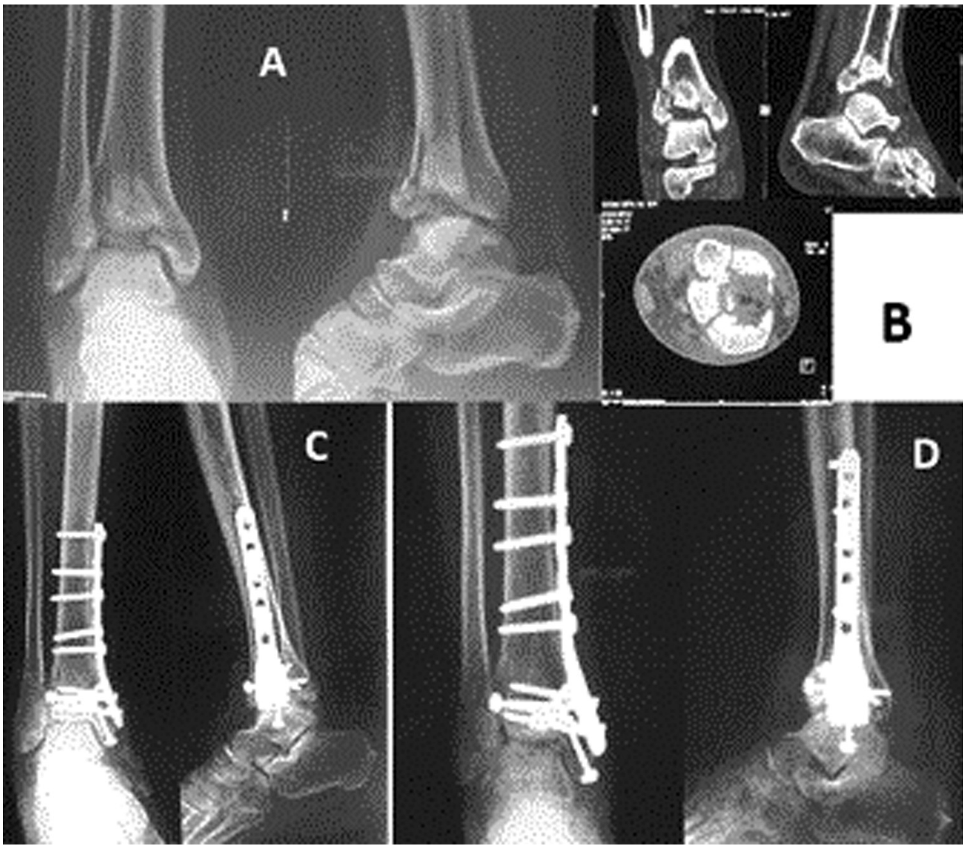
The mean AOFAS score at final follow-up was 79. The full results of the AOFAS ankle hindfoot scale are given in Table 3. Excellent clinical result was achieved in 21 (65.6%) ankles, good in nine (28.1%) ankles, and poor in two (6.3%) ankles. Complications are shown in Table 4.

Discussion

Many options are available for the treatment of tibial pilon fractures. The choice of treatment is determined according to the fracture type and soft tissue injury pattern [14]. Ruedi and Allgower [15] reported their classic pilon fracture treatment principles in 1979, which include restoration of fibular length, anatomic reduction of tibial articular surface, bone grafting for metaphyseal defects, and medial buttress plating. Soft tissue complications are adherent disadvantages to choosing the ORIF treatment option.

Teeny and Wiss [4] reported on 60 pilon fractures in patients who were treated with plating techniques. Thirty of these injuries were Ruedi type III, the majority of which were high-energy fractures. The

Figure 2



(a) Anteroposterior (AP) and lateral radiograph of a 35-year-old male patient who sustained closed right ankle pilon fracture with Tscherne type 1 soft tissue injury in a road traffic accident. (b) Computed tomography scan showing AO/OTA 43-C3 pilon fracture. (c) Postoperative AP and lateral radiograph showing excellent reduction. (d) Follow-up AP and lateral radiograph showing 0.5-mm displacement of medial maleollus and 1-mm displacement of lateral chaput fragment.

Table 3 Results of the American Orthopedic Foot and Ankle Society score

AOFAS-items	Mean result (minimum–maximum)
Pain (maximum 40)	34.8 (0–40)
Function (maximum 28)	25.3 (0–28)
ROM (maximum 22)	19.4 (0–22)
Alignment (maximum 10)	9.5 (0–10)
Total (maximum 100)	79 (49–97)

AOFAS, American Orthopedic Foot and Ankle Society score; ROM, range of motion.

results differed from the results of prior studies because they were based on the fracture classification. The results for patients with type III fractures generally were poor. Overall, 50% of the patients had significant wound complications, and 37% had a deep infection. The authors concluded that in the severe fracture patterns, if a less than anatomic reduction was achieved and the soft tissue sleeve was compromised, then severe complications such as skin slough, wound dehiscence, infection, loss of fixation, malunion, and nonunion were likely. In these situations, alternatives to standard open reduction and internal fixation techniques were recommended.

The vascular supply to the distal tibia can influence the ultimate healing process of the fracture. In the tibial plafond, there is a limited and precarious blood supply owing to the minimal soft tissues surrounding the distal tibia. Additional soft tissue stripping required for reduction and fixation further compromises the vascularity to the bony fragments and surrounding soft tissues. It can be argued that articular reduction leads to a better outcome [16]. Even though immediate postoperative radiographs may indicate an anatomic reduction, the ultimate outcome is often influenced by the fate of the articular cartilage. The combination of avascular necrosis of bony periarticular fragments and a latent manifestation of undetectable cartilage damage often ends in posttraumatic arthritis in higher-energy injuries. Furthermore, the perioperative consequences of soft tissue damage are often devastating [17].

Minimally invasive surgical approach for the stabilization of distal tibia fractures is desirable as it reduces the risks of soft tissue and bone healing disturbances. The MIPO technique could make it possible to reduce these complications and therefore allow an early intervention in a single procedure. In 32

Table 4 Complications

Complication	Number of ankles (*n*=42)
Wound complications	
Superficial infection at distal incision	5
Deep infection	1
Post-traumatic arthritis	
Due to immediate postoperative unsatisfactory reduction	3
Due to deep infection	1
Reoperations	
Autologus bone graft for delayed union	4
Ankle arthodesis[a]	2
Plate removal[b]	10

[a]None of the patients underwent a primary arthrodesis, but in two ankles, arthrodesis was performed later. Arthrodesis was performed after 12 months in a case that developed deep infection and after 24 months in a case that developed post-traumatic arthritis owing to unsatisfactory reduction. [b]Plate removal after 12–18 months owing implant prominence, irritation under the skin, and pain.

fractures operated in the first 36 h, Leonard *et al.* [18] reported only one malunion, with no deep infection at 2 years. In this series of the same number of pilon fractures that were managed after a mean of 1.3 days of injury, we had satisfactory postoperative reduction in 90.9%, satisfactory clinical results in 93.7%, and only one deep infection.

Ahmed *et al.* [19] in a series of 18 patients with pilon fracture managed by MIPO achieved fracture union in 16 patients. The average time to union was 32 weeks. Five (27%) of the 18 patients developed complications. There was one superficial wound infection, and one chronic wound infection, resulting in nonunion. Two patients required plate removal, and one patient had implant failure.

In a series of pilon fractures treated with ORIF, the reported rates of bone grafting have varied, but most studies report rates between 40 and 50% [17,20,21].

In our study, four (12.5%) cases had a later autologous iliac bone graft for delayed union. Our lower rate of bone grafting may be attributed to supraperiosteal insertion of the plate and low soft tissue-related complications.

Several authors have recommended operative stabilization of the fibula. The premise is that it adds lateral stability and provides a 'starting' point for reconstruction [22]. In this series, the fibula was fractured in 10 ankles; the fibula was fixed by k-wire in two ankles with infrasyndesmotic fractures causing talar tilt with stress varus. A nonweight-bearing below-knee removable splint was applied in these ankles. We believe that proximity of the two incisions can increase soft tissue problems. In addition, indirect reduction of the fibula can be used as a guide of proper reduction of pilon fracture.

Unsatisfactory functional results are often owing to prolonged immobilization because of a fear for loss of reduction. Loss of reduction by the insufficient hold of the screws in the area of a comminuted fracture of a mainly cancellous bone leads to a loss of reduction in up to 11%, with arthrodesis rates of 9–11%. Especially in cases with osteoporosis, a high primary stability is difficult to achieve [23]. We could show that with a locked plate-screw connection, secondary loss-of-reduction rates are very low. In our study, there is no statistically significant difference ($P>0.05$) between immediate postoperative reduction and reduction at the final follow-up.

The most common long-term complication after a tibial pilon fracture is post-traumatic arthritis. Radiographic findings of posttraumatic arthritis may not always correlate with the patient's symptoms or reported disability. The most reliable treatment of symptomatic posttraumatic ankle arthritis is arthrodesis [24].

Studies have shown that the final functional result after pilon fractures correlates strongly with the accuracy of articular reduction. Four patients in our series had radiological evidence of ankle joint arthritis at the final follow-up. Two (6.3%) of them required ankle arthrodesis. A review of literature reveals that studies reporting results of ORIF for pilon fractures quote a salvage arthrodesis rate of 0–26% [25]. We feel that early reduction with the use of locked plates allowed accurate reconstruction of the articular surface, thus reducing the incidence of joint problems.

Angular malunions have widely been reported in distal tibia fractures. Prevention of secondary malalignment is largely dependent on biomechanical features of the implant and the implant to bone interface [26]. The uses of locked plate in this study minimize malunions to three ankles, two of them were mild does not affect the final result.

Conclusion

(1) Acute surgical intervention leads to better immediate postoperative reduction.
(2) Minimally invasive surgical approach for the stabilization of distal tibia fractures reduces the risks of soft tissue and bone healing disturbances.
(3) With locked plate-screw connection, secondary loss-of-reduction rates and malunion are very low.
(4) Stabilization of the fibula as a first step in management of tibial pilon fracture is not mandatory.

Therefore, the use of acute minimally invasive approach combined with locking plates for the treatment of complex pilon fractures decreases complications associated with disruption of the soft tissue envelope and associated osseous complications and allows quicker return to function.

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Conflicts of interest
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

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