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Case Report

Gradual distraction on hinged-based Ilizarov ring fixator to correct fixed flexion deformity of knee: description of the surgical technique

Anil Regmi, Bishwa B. Niraula, Shivam Bansal, Rohan Gowda, Saptarshi Barman, Mohit Dhingra*

Department of Orthopedics, AIIMS, Rishikesh, Uttarakhand, India

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***Correspondence:**
Dr. Mohit Dhingra,
E-mail: modisbanu77@gmail.com

ABSTRACT

Knee deformity in flexion is the most disabling deformity. Surgical correction can be attempted with soft tissue release, osteotomy, or both. However, acute correction can cause serious complications. Ilizarov technique has become an appealing alternative to open surgery, where skeletal traction is used to distract the joint gradually and steadily in order to reduce the risk of skin problems or neurovascular injuries. Two patients and three limbs, male aged 28-42 (mean=35 years) with severe fixed flexion deformity were corrected by a hinged-based Ilizarov ring fixator. Mean flexion of the knee was pre-operatively 86.66 degrees (80-90 degrees). The mean extension angle at the last follow-up was 168.3 degrees (165-170). The mean knee society score (KSS) was 44.3 (35-50), mean KSS functional score was 43.3 (0-65). One patient had satisfactory outcomes and could stand without walking aids and walks on extended knee with walking aids. Arthrodesis of knee or creating a stiff knee in the most extended position may be most effective for **s**evere, fixed contractures. With the gradual, calculated distraction, the Ilizarov apparatus is an effective tool for treating severe cases of knee contracture.

Keywords: Stiff knee, Flexure contracture, Ilizarov, Deformity correction, Knee arthrodesis, Osteotomy

INTRODUCTION

A patient with a fixed flexion deformity may be disabled since the lower limb cannot bear weight.[1] In the absence of treatment, knee flexure contractures can cause severe disability, requiring patients to use crutches or wheelchairs.[2] Several surgical procedures have been proposed for treating fixed flexed knees. Depending on the severity of the deformity, it will receive different treatments.[1]

Treatment options for knee flexion deformities include physiotherapy, splinting, soft tissue release, serial casting, and arthrodesis in extension. In addition to soft tissue release, osteotomy or a combination of the two can be used to treat fixation knee contractures.[3] It is important to note that acute correction can result in complications like injuries to the popliteal artery, peroneal palsy, knee subluxation, hyperextension, skin necrosis, and recurrence.[4]

In the Ilizarov technique, skeletal traction is used to gradually distract the joint and reduce the risk of skin or neurovascular problems. The procedure has become an attractive alternative to open surgery.[5] External fixators such as the Ilizarov circular fixator, the monolateral fixator, and the hinged distraction apparatus have been used to correct deformities.[6]

In this paper, we present a series of cases with a stiff knee in flexion, which was managed by a hinged-based Ilizarov ring fixator with gradual distraction using the law of a similar triangle.

Surgical technique

Between January 2022 to March 2022, 2 patients with three limbs of severe fixed flexion deformity were corrected by a hinged-based Ilizarov ring fixator, and gradual distraction was done to correct the flexion deformity, where the distraction at the hinge and the telescopic rod was done by using the law of similar triangle.[7] The final aim was to provide arthrodesis of knee in extension in two limbs and deformity correction in one limb.

In the law of a similar triangle, the measurements are calculated at a plain radiograph on the lateral view where, correction time and rate of distraction can be calculated.

For the calculation of correction time:

$$Time = Distance/Rate\ of\ distraction$$

$$Distance = 2\pi r(r \times d)/360$$

Where r=radius, 2πr=length of circle's circumference, and d=deformity angle.

For calculation of the rate of distraction:

$$Rate\ of\ distraction = distance\ a/distance\ b$$

Where, distance a: distance between the apex of an overlapped hinge to the posterior cortex of the knee joint, and distance b: distance between the apex of the hinge to mid-point of two connecting/telescopic rods connecting proximal-most and distal-most rings posteriorly.

The calculated measurement was round-offed and distraction was done at the same ratio achieved at calculation on a hinge and telescopic rod till the calculated correction time or desirable clinical correction whichever earlier, as shown in Figure 1.

Patients were appropriately instructed to perform daily distraction according to the law of a similar triangle at home, and hospital visits every two weeks until complete distraction. At home, patients were monitored telephonically over telephonic or video-assisted phone calls whenever in doubt. The clinical and radiological outcome was analyzed at every two-week interval post-operatively up to the completion of distraction. After achieving the acceptable correction, distraction was stopped, and Ilizarov's frame was maintained in a stable position to achieve a bony union.

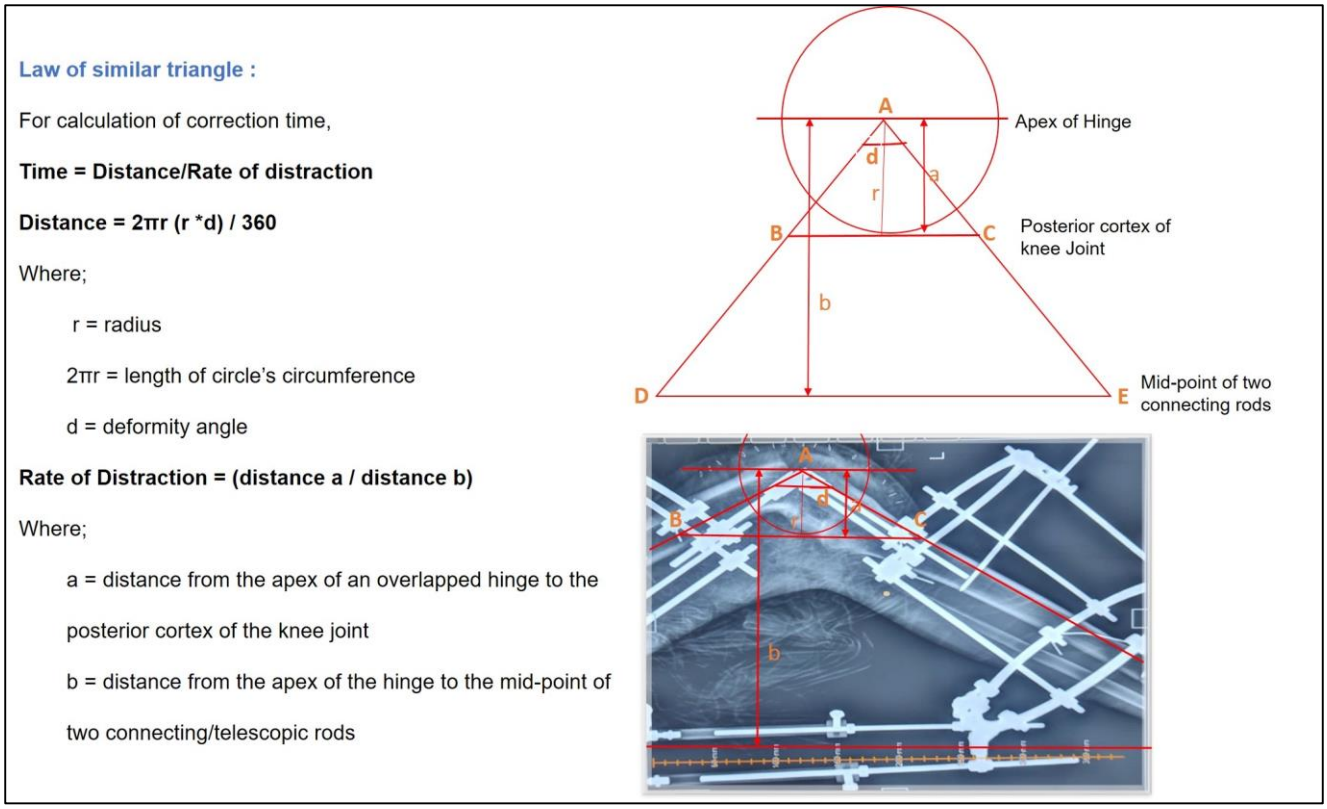

Figure 1: Representative image for the calculation of the rate of distraction from the law of a similar triangle.

Patients were subjected to rectifying the union process by Accordion maneuver in a stable Ilizarov frame whenever there was suspicion of the delayed union on clinical and radiographic findings. Patient satisfaction, VAS score, KSS knee score, and KSS functional score were measured and analyzed at the final follow-up and summarized in Table 1.

CASE REPORT

Two patients with three limbs, where two limbs were idiopathic bony ankylosed knees, and one was a case of the post-traumatic neglected fixed flexed knee. Both patients are male, with the patient's age (mean=35 years) being 28 years in the bilateral bony ankylosed case and 42 years in the post-traumatic neglected fixed flexed knee. A hinged-based Ilizarov ring fixator was applied on all three limbs, where open anterior wedge osteotomy was done on both ankylosed limbs, and a closed Ilizarov ring fixator was used in the post-traumatic neglected fixed flexed knee. The mean flexion of the knee pre-operatively was 90 degrees (80-100 degrees). The mean duration of distraction on the Ilizarov ring fixator was 88 days (62-140 days). At the final follow-up, all the patients had fully corrected flexion contracture, which was a significant improvement from their preoperative condition. The mean extension angle at the last follow-up was 168.3 degrees (165-170). The mean KSS score was 44.3 (35-50), mean KSS functional score was 43.3 (0-65). These patients did not experience any severe complications during treatment. However, a few minor complications were noted; pin tract site infection (n=6), and broken pin (n=1). The mean pin tract site infection was 2 (1-3). The bilateral knee patient had satisfactory clinical outcomes and could stand without walking aids and walk on his o extended knee with walking aids. The post-traumatic knee patient had a persistent residual posterior subluxation, had neutral clinical outcomes, and could stand and walk on his extended knee with walking aids, summarized in Table 1.

Case 1

Thirty-one-year-old male presented with complaints of progressive flexion deformity of the bilateral knee with limping and difficulty in weight bearing on bilateral lower limbs for the last nine years. There was no history of significant trauma. On past history, the patient was a known case of psoriasis diagnosed 15 years back, non-medicated. Rest family and past history were insignificant.

At presentation, the patient had a crouch gait with bilateral crutch support (Figure 2a). On examination, bilateral fixed flexed knee of 80 degrees on the right and 90 degrees on left were present (Figure 2b and c). Distal Neurovascular status was intact. Knee Range of motion was restricted entirely at fixed flexion.

Plain radiographs showed bilateral fixed flexed knee, with gross bony ankyloses (Figure 2d and e). Preoperative CT angiography was performed to see the course of popliteal vessels for preoperative planning, which shows the normal caliber of vessels with adequate blood flow to lower limbs bilaterally.

A final diagnosis of bilateral stiff knee in flexion due to bony ankylosis secondary to psoriatic arthropathy was made. With due consent of the patient, the patient was planned for deformity correction by anterior wedge osteotomy and knee spanning hinged-based Ilizarov fixator application consecutively one after another (Figure 2f and g). The first left side was operated on, and gradual distraction started according to the law of a similar triangle, where the distraction rate was 1:6. The patient was on gradual distraction for 98 days on the left lower limb to achieve the extended knee of 170 degrees. Then, the Ilizarov frame was kept in place for additional 22 days to achieve stable bony fusion (Figure 2i). The Ilizarov frame was removed 120 days after that limb was maintained on the cylindrical cast for two weeks to maintain the fixed extension. During the course of the left lower limb, the patient developed a pin tract infection at one pin, which was managed by the daily dressing of the pin tract site.

Similarly, the right side was operated on after 32 days of the left side, with a similar procedure of anterior wedge osteotomy and knee spanning hinged based Ilizarov fixator application and distraction done at the rate of 1:4, according to the law of similar triangle, for 106 days to achieve the extended knee of 165 degrees. Then, since there was a gross abnormality on the Ilizarov frame was kept in place along with the accordion maneuver, where alternate compression and distraction of 7 days each, for three cycles (42 days) to achieve stable bony fusion (Figure 2h). The Ilizarov frame was removed at 148 days after that limb was maintained on the cylindrical cast for two weeks to maintain the fixed extension. Then the patient was advised to return to daily activity with the stable knee in extension.

During the course of the right lower limb, the patient developed pin tract infection at two pins, which was managed by local curettage followed by the daily dressing of the pin tract site in one pin tract site, and only daily dressing of the pin tract site in next pin tract site. At the final follow-up, the patient could stand without support and walk on his own with an extended knee with the support of walking aids (Figure 2j).

Case 2

A 42-year-old male presented with complaints of pain along with flexion deformity of the left knee and unable to bear weight on his left lower limbs for the last year. There was a history of falls from a significant height one year back, with posterior dislocation of the knee and severe head injury. The patient was treated elsewhere for a severe head injury; the closed reduction was done and immobilized for posterior knee dislocation. Later patient developed extended cellulitis on the leg, for which multiple soft tissue surgeries were performed on the left leg along with the amputation of gangrenous toes within the past year. Family and other past history were insignificant.

At presentation, the patient was wheelchair-bound and unable to mobilize due to gross deformity of the left lower limb. On examination, knee was fixed and flexed at 90

degrees, with multiple healed scar marks with a thick flap over the leg, great toe, second and third toe were amputated with the healthy stump (Figure 3a). Active ankle and toe movement were absent. Knee Range of motion was restricted entirely at fixed flexion of 90 degrees.

Plain radiographs of the left knee showed a fixed flexed knee with posterior subluxation of the knee (Figure 3b).

A final diagnosis of neglected posterior dislocation with stiff knee in flexion left side was made. With due consent of the patient, the patient was planned for deformity correction by knee spanning hinged-based Ilizarov fixator application followed by a gradual distraction according to the law of a similar triangle, where the rate of distraction was 1:4 (Figure 3c and d).

The patient was on gradual distraction for 78 days, to achieve an extended knee of 170 degrees. Due to poor compliance with distraction and uncomfortable with the Ilizarov frame, patient does not want to maintain the frame further. Hence, removed on 78 days, where the extended knee was achieved; however posterior subluxation component still persists, which was accepted by patient rather than further maintaining the Ilizarov. During the course, the patient developed a pin tract infection at three pins, which was managed by a daily dressing of the pin tract site, and there was one broken pin on the femur, for which the next pin adjacent to the broken pin was applied under regional anesthesia, and integrity of frame was maintained. At the final follow-up, patient was able to stand on his own with support from an extended knee (Figure 3e).

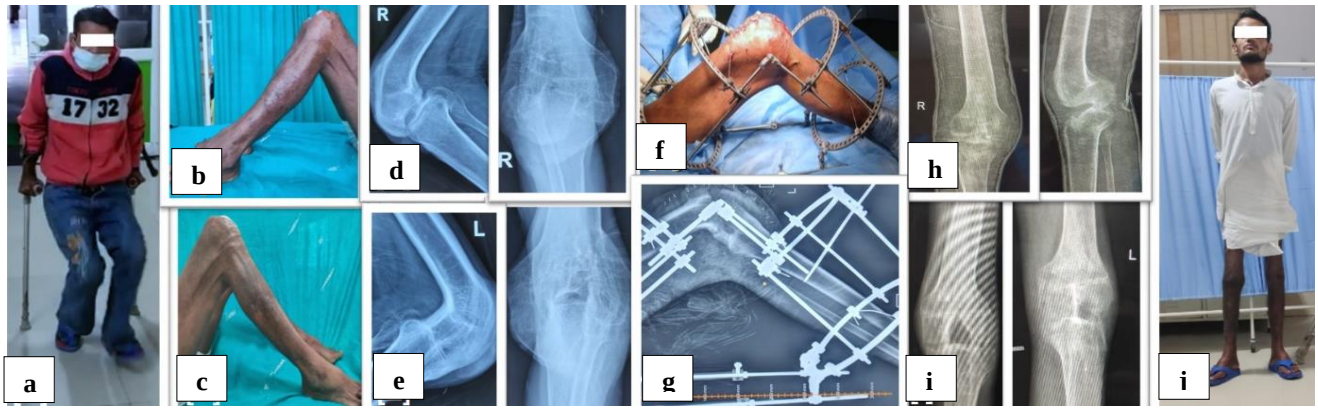

Figure 2: Representative images of case 1: (a) clinical image at presentation showing crouch gait with bilateral crutch support; (b) and (c) gross wasting bilateral lower limbs of muscles with the gross bilateral fixed flexed knee of 80 degrees on the right and 90 degrees on left; (d) and (e) plain radiographs showing bilateral fixed flexed knee, with gross bony ankyloses; (f) intra-operative image of left lower limb after deformity correction by anterior wedge osteotomy and knee spanning hinged-based Ilizarov fixator application; (g) post-operative radiographs showing Ilizarov fixator in place where distraction started according to the law of a similar triangle; (h) and (i) radiographs at final follow-up showing extended knee with stable bony fusion; and (j) clinical image at final follow-up, where patient could stand without support and walk on his own with an extended knee with the support of walking aids.

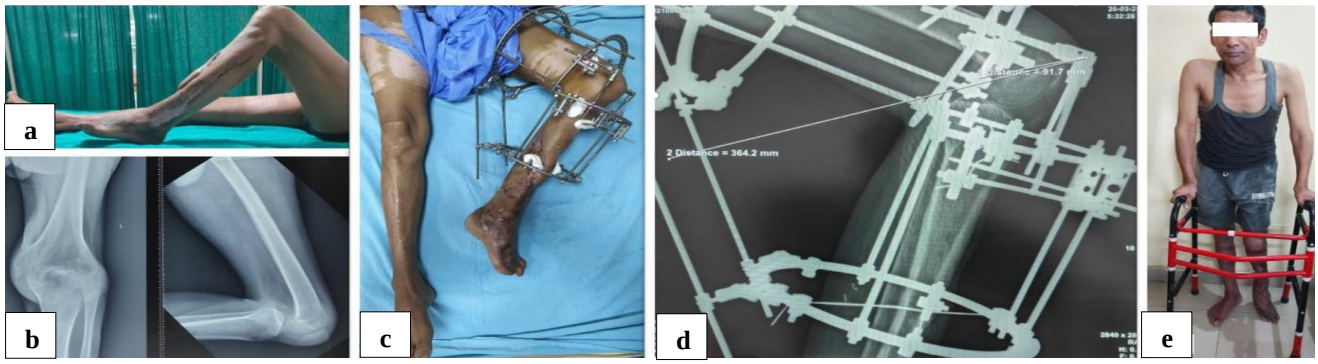

Figure 3: Representative images of case 2: (a) clinical image showing left hip and knee flexed, along with multiple healed scar marks with a thick flap over the leg, great toe, second and third toe were amputated with the healthy stump; (b) plain radiographs of the left knee showed a fixed flexed knee with posterior subluxation of the knee; (c) post-operative image of lower limbs after knee spanning hinged-based Ilizarov fixator application; (d) post-operative radiographs showing Ilizarov fixator in place where distraction started according to the law of a similar triangle; and (e) clinical image at final follow-up, where patient was able to stand on his own with support from an extended knee.

Table 1: Summary of the study.

Parameters	Case 1		Case 2
Age (years)	28		42
Sex	Male		Male
Symptoms	Stiff knee		Pain, stiff knee
Duration of symptoms	9 years		1 year
Gait	Bilateral Croutch gait		Wheelchair-bound
Cause of stiff knee	Idiopathic/psoriatic arthropathy		Neglected post-traumatic posterior knee dislocation
Procedure performed	Ilizarov fixator application + anterior wedge osteotomy		Ilizarov fixator application
Side	Right	Left	Left
Pre-operative flexion	80	90	90
Rate of distraction	1:4	1:6	1:4
Distraction days	106	98	78
Additional Manoviur	Accordion method for 3 cycles	-	Anterior distraction of proximal tibia for 10 days
Ilizarov days	148	120	78
Final extension	165◦ extension	170◦ extension	170◦ extension
Status	Bony fusion achieved	Bony fusion achieved	Desirable extension achieved, residual posterior subluxation still present due to premature removal of Ilizarov to poor compliance
KSS knee score	48	50	35
KSS functional score	65	65	0
Complications	Pin tract site infection (2)	Pin tract site infection (1)	Pin tract site infection (3), broken pin (1), residual posterior subluxation
Patients perspective	Satisfactory	Satisfactory	Neutral
Clinically	Patient able to stand and walk on his own with extended knee		Patient able to stand with support on an extended knee

DISCUSSION

There are several severe disabilities associated with flexion contracture of the knee.[8] This group of patients needs treatment to become ambulant, energy-efficient, independent, and functional, as well as to improve their self-esteem.[9] Surgical procedures are required in cases of severe contractures with flexion deformities of 30°.[10] The release of posterior soft tissues, supracondylar extension osteotomy, and mechanical distraction with external fixators are optional; however, none have been accepted worldwide.[3,10,11] In our case, the patients had fixed flexed knees with mean flexion of 90 degrees (80-100 degrees), also both patients were disabled for their daily life due to severe deformity of lower limb(s). In this study, considering the deformity of patients, the aim of the planned operative procedure was to provide a stiff knee in the most extended position, so that patient can be mobilized in an acceptable gait with an extended knee.

With soft-tissue releases and osteotomies, acute correction can result in incomplete correction or overcorrection, with significant skin complications, nerve traction injuries, and recurrence risks.[12] Knee joints are continuously and slowly distracted by the Ilizarov technique, according to the law of tension stress, where tissues are subjected to gradual, controlled traction to simulate normal growth.[6] Compared with open surgery, the Ilizarov technique reduces complications such as neurovascular injury, bone non-union, internal fixation failure, and deep infection.[9] In this study, two limbs were subjected to anterior wedge osteotomy considering the bony ankylosed knee where only distraction wouldn't help in the correction of bony deformity. Although osteotomy was performed, the distraction was done gradually by a hinged-based Ilizarov ring fixator according to the law of similar triangles to achieve the desired correction, so that the complications of acute correction were prevented.

Some complications may occur with the Ilizarov apparatus, such as pin tract infection, knee flexion loss, and flexion contracture recurrence.[6] Infections of the pin tract are the most common complication of the Ilizarov technique, occurring at a rate of between 5.12 to 100%.[13] Another common problem with the Ilizarov method is the loss of knee flexion, where 6.7° in range of motion was observed to be decreased in the postoperative period in the study by Balci et al.[14] In the current study, pin tract site infection was the most common complication encountered where, an average of 2 pins per limb were infected which were managed conservatively by daily dressing and/or local curettage. Another complication encountered with Ilizarov was a broken pin, seen in one case, where the next

pin adjacent to the broken pin was applied under regional anesthesia to maintain the integrity of the frame. Here, the procedure was performed to provide a stiff knee in the most extended position, the loss of flexion as a complication does not come into account. Contrary to other reports, we did not suffer from neuropraxia, epiphyseal separation, coronal plane deformities of the knee, plastic deformation of bone, iatrogenic fractures, or stress fractures. However, there was residual posterior knee subluxation in one case, which was due to poor compliance with distraction and premature removal of the Ilizarov fixator due to non-adherence to the frame of Ilizarov's because of its complex structure.

The majority of available reports on Ilizarov soft tissue distraction for knee flexion deformity show good outcomes.[1,2,5,6,9,11-15] Gradual distraction with Ilizarov has certain advantages like reducing the risk of neurovascular complications by distracting the joint slowly and steadily at one millimeter per day, which matches with the normal nerve regeneration process after axonotmesis where nerves regenerate at a rate of one millimeter per day.[6] Although there was no associated nerve injury in these cases, the stretching of the nerve and its regeneration during the distraction yield no neurological symptoms later.

Distraction osteogenesis has been accelerated using dynamization by accordion maneuvers.[10] Alternate compression-distraction was performed twice a day for seven days at a rate of 0.25 mm; then, the opposite maneuver was performed at the same rate.[16] It helps to improve bone formation during distraction osteogenesis by transforming the newly weak callus into fibrovascular tissue, and repeated distraction stimulates the collagen fiber and osteoblastic cell production, which leads to the intramembranous ossification of bones.[17] In the current study, due to a gross abnormality on the Ilizarov frame, one limb was subjected to an accordion maneuver, where alternate compression and distraction were applied for three cycles (42 days) to achieve stable bone fusion.

This study is limited by a small sample size, and the follow-up period was short. A long-term follow-up study of hinged-based Ilizarov ring fixator application in a flexed stiff knee and its long-term outcomes is needed.

CONCLUSION

Severe, fixed contractures at the knee remain one of the most challenging deformities. Several solutions can be considered, but arthrodesis of the knee or creating a stiff knee in the most extended position may be most effective. With the gradual, calculated distraction, the Ilizarov apparatus is an effective tool for treating severe cases of knee contracture, but every step must be carefully monitored.

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Ethical approval: Not required

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