

A new application technique of circular fixator for the treatment of open tibial fractures: circular fixator-hinge technique

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ABSTRACT

BACKGROUND: The purpose of this study is to present and validate a hinge-fixator technique for the treatment of open tibial fractures, which has advantages in application and the follow up period.

METHODS: The technique was used in open tibia fractures of 14 adult patients. Using this method, initial anatomic reduction was achieved and temporary stability was obtained on the hinge-fixator after applications were completed. Patients' radiological and clinical results were analyzed using the Paley's criteria at the time of the last follow-up.

RESULTS: Patients were brought in for followed up analysis over a 5.4 year period. According to Paley, two patients had 'good' and 12 patients had 'excellent' radiological results, while the functional result were excellent (n=13) and good (n=1), respectively.

CONCLUSION: The hinge-fixator technique is a fast and easy method that contributes to shorter operation times, reduced radiation exposure, and more comfortable treatment periods.

Key words: Circular fixator; hinge technique; tibia fracture.

INTRODUCTION

External fixators have long been used for fracture treatment. Since the introduction of the Ilizarov method, these fixators have gained the widespread use. Nevertheless, the basic principles of fixation techniques have not been changed, although intensive technologic developments have been recorded.^[1-4]

Even though the circular fixators are not the first choice for the treatment of simple fractures, they are often preferred for complex fractures associated with soft tissue damage.^[5,6] One of the greatest advantages of the circular fixators are their application to various traumatic extremities with a reduction in infection rates.^[7,8] The most important disadvantages

of the method are patient discomfort during the follow up, patient compliance adjustments are needed, and external fixation devices are more difficult to learn compared to other methods.^[9-11]

The purpose of this study is to present the circular fixator technique for the treatment of open tibial fractures. Our findings demonstrate that the circular fixator technique has major advantages in application and in the follow up period for treating open tibial fractures. Using this technique, the fragments are fixated to a simple hinge-fixator frame and the final stabilization is performed after the fracture is reduced. In addition, the duration of the operation can be shortened and the traction of the pins and wires harming the soft tissue by tension is minimized. Thus a more comfortable treatment option is facilitated.

MATERIALS AND METHODS

The method was used in open tibial fractures of 14 adult patients. Ten of the patients were male and four were female with the mean age of 41.3 years (range 24-58). Tibial fractures were located on the right side in 10 patients and on the left side in four patients. Based on the AO classification system, there was one patient with type A2, one A3, one B1, five B2, two B3, two C1 and two C2 fractures, respectively.

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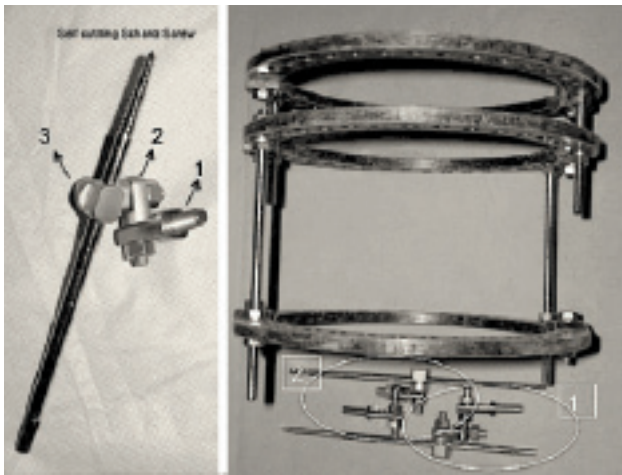


Figure 1. Hinge system was obtained by combining three offsets where each offset is perpendicular to the former one. The hinges can freely move in coronal, sagittal and transverse planes as a natural result of this binding style (The numbers 1,2,3 depicts offsets and Schanz pin in the picture). One hinge is prepared for each major fragment.

According to the Gustilo-Anderson classification, there were three cases of grade 2 fractures, three cases of grade 3a, six cases of grade 3b, and two cases of grade 3b. The most frequent etiologic factors for fractures were motorbike and car accidents.

Standard anterior-posterior (AP) and lateral graphics were obtained for surgical planning as well as for the follow-up. The lengths of the extremities were evaluated by comparing with the opposing tibia if the fractures were comminuted or segmented.

All patients underwent operative treatment within an average of 10.7 hours after the injury (range from five hours to seven days). All operations were performed in supine position, under fluoroscopic guidance by the same surgical team on a radiolucent operating table. 10 patients had general anesthesia whereas four had spinal block anesthesia. A tourniquet was not used in any of the patients. In two Gustilo-Anderson grade 3b fracture cases, flap coverage of the skin defects were performed before the fixator application. Duration of operation, intra-operative fluoroscopy time, and number of maneuvers performed for reduction of the fractures were recorded in the operation theater. The accompanying fractures were also treated in the same session but the data were collected just for the tibial fractures. The time spent in the external fixator and time-to-weight bearing/walking were also recorded. All data were collected by reviewing the patients' medical records.

Patients' radiological and clinical results were evaluated according to the Paley's criteria at the time of last follow-up.^[12,13] On the plain radiographs, angles between the anatomic axis of the proximal and distal segments were evaluated,

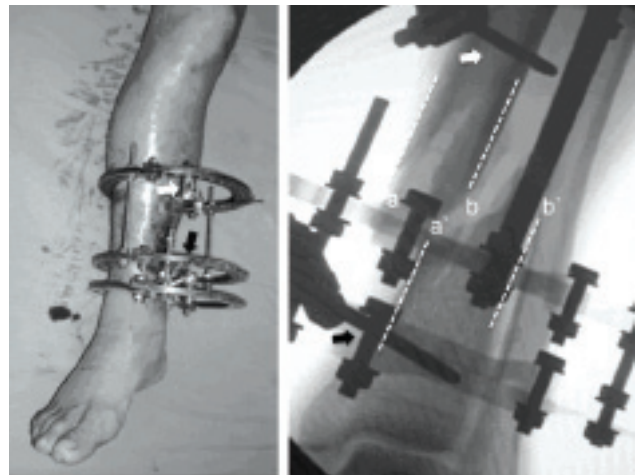


Figure 2. Fragments are fixed by Schanz pins sent through the hinges. The picture shows a-a' and b-b' as amount of fracture displacement. At this stage, reduction was still not performed.

while varus-valgus or procurvation-recurvation deformities were recorded. Complications were also recorded according to Paley's complication classification.^[14]

Surgical Technique

In this hinge-fixator system, first the standard circular fixator frames were prepared. The hinge system was obtained by combining three offsets (a standard component of fixator elements), where each offset was connected perpendicular to the former one. As a result, the hinge system was able to perform free rotational movement in coronal, sagittal, and transverse planes (Figure 1). Separate hinge systems were prepared and connected to the medial side of the rings for each fracture segment. These segments were fixed with Schanz screws inserted through the hinge system (Figure 2). Reduction of the fracture site was obtained by longitudinal traction. Rotation was controlled by checking the alignment of the anterior tibial crest of the distal fragment with the proximal part. After achieving anatomical reduction (which

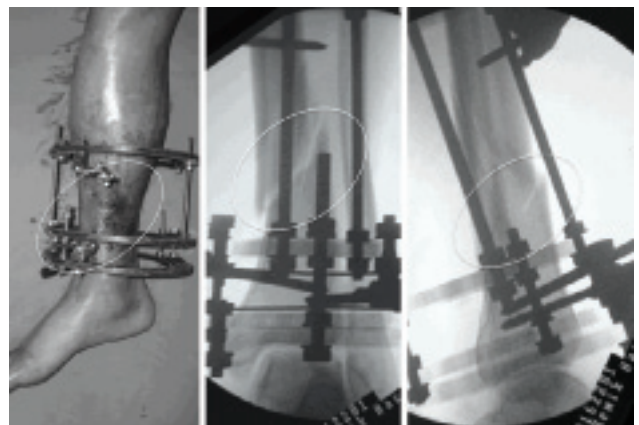


Figure 3. The photograph of leg after reduction, the fracture is fixed temporarily on the hinge-fixator. Antero posterior and lateral views showed a nearly anatomic reduction.

was confirmed by fluoroscopy), the screws of the hinge system were tightened. Thus, the fracture was fixedated in an anatomic position with the fixator frame (Figure 3). Subsequently, the stabilization was achieved by applying the wires and completing the fixator application (Figure 4).

If the fracture was segmented, a separate fixator-hinge level was used for the middle major fragment. For these types of fractures, reduction was applied for each segment, and the length of the extremity was adjusted according to the opposing tibia or according to the fibular length.

RESULTS

The mean duration of the operation was 61.14 (45-100) minutes, and the intra-operative fluoroscopy usage was 6.4 (5-12) images/patient. The average number of maneuvers performed for the reduction of the fractures was 2.7 (2-4) times. The average post-operative hospitalization period was 3.5 (2-8) days. None of the patients required additional reduction after surgery. Time to full weight bearing walking after surgery was 2.78 days. The number of postoperative follow up visits was 3.9 (3-7) times. The mean time spent in external fixator was 5.1 (4-5.8) months.

According to pin tract infection classification of Paley, 12 patients had grade 1 (inflammation) and five patients had grade 2 (soft tissue infection) pin tract infection. One patient had

a wire break and fortunately did not require any additional surgery. Solid osseous union was achieved with all patients. Patients were followed up 5.4 (3-8) years. At the final visit, patients were graded according to Paley's radiologic scale.



Figure 4. After reduction, the desired stabilization is obtained by completing the fixator application. Antero posterior and lateral graphics of a cruris at postoperative four months which reveals union.

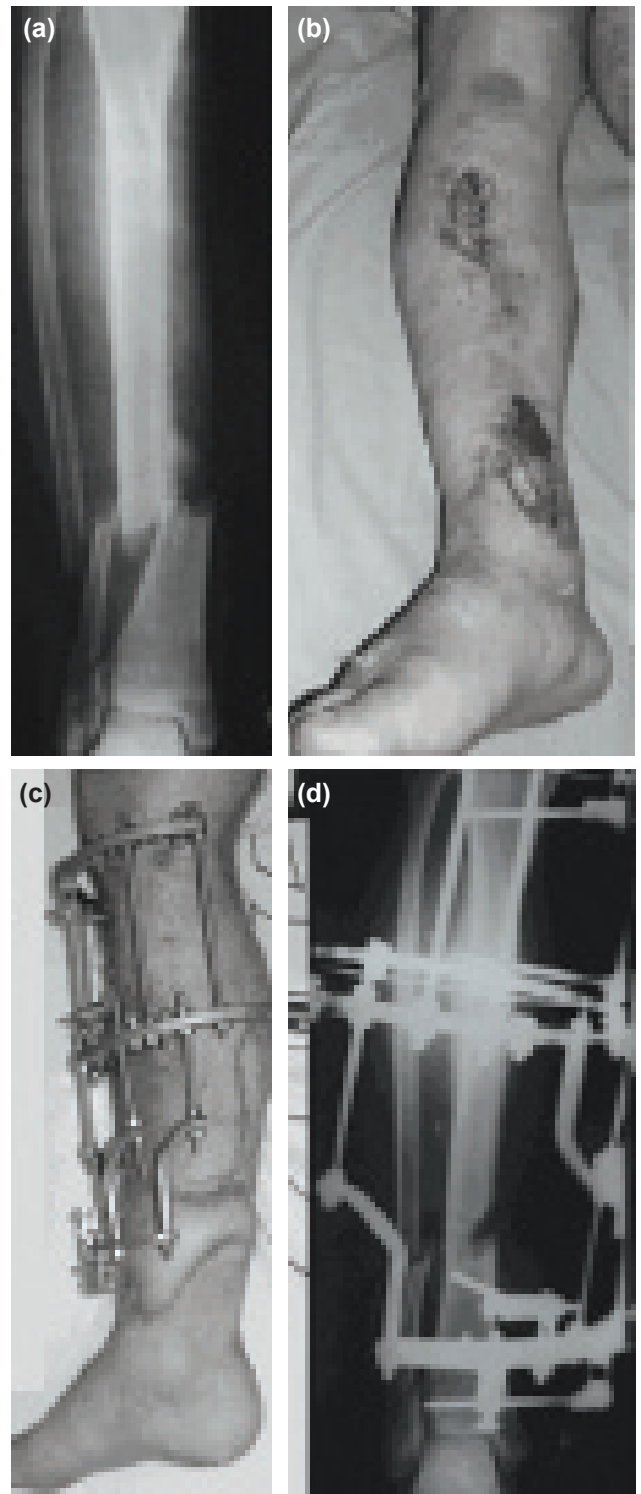


Figure 5. Fixator should be modified according to surgical procedure. (a) Radiologic anterior-posterior view, (b) pre-operative photograph of the cruris (c) a modified fixator applied and (d) follow up imaging.

Two patients were good (one patient had 10 degrees translation deformity and one patient had 15 degrees recurvation deformity) and 12 patients were excellent. According to the clinical evaluation, 13 patients were excellent and one patient was good (2 cm shortness). No rotational deformity was detected in any of the patients. As stated above, a single patient with segmental tibia fracture showed 10 degrees of translation deformity, while another showed 15 degrees of recurvation deformity, but no additional treatment was required in both patients.

DISCUSSION

One of the most important advantages of the hinge-fixator technique is that the reduction of the fracture is made at the initial stage. Thus, soft tissues re-locate to their original positions, and pins and wires do not lead to tractions in soft tissues. The size and weight of fixators are one of the major factors that affect patient's compliance and comfort.^[10,14] In our practice, fracture reduction is made just after inserting the first Schanz screws, and so the stabilization can be obtained by a smaller fixator. In addition, if a local or distant flap is applied for the patient's soft tissue coverage, fixator may be modified according to the condition of the leg so that it may improve patient compliance and comfort (Figure 5).

Although anatomic reduction may be obtained in the treatment of fractures by open reduction and internal fixation, there are some disadvantages of this procedure such as healing delay, infection, and soft tissue damage.^[15-17] In conservative treatment methods, some of these listed disadvantages can be eliminated, but obtaining good reduction and stable fixation still pose a problem.^[18] On the other hand, treatment of fractures with external fixators can be considered as a "semi-conservative" method between surgical treatment and conservative methods. From this point of view choosing circular external fixators in the treatment of severe open fractures may prevent many possible complications.^[18-20]

There is a general consensus that better reduction result in earlier and stronger union outcomes.^[5,17,21] In conservative treatment methods, plasters or braces have limited effects on maintaining stable reduction. From this point of view, hinge-fixator systems may be accepted as a "sophisticated brace". In this method, reduction may be protected in a stable way, where functional use of extremity can also be possible during the treatment period.^[1,4,7]

Reduction of the fracture is mainly based on applying traction and manipulation. In order to achieve a successful reduction, soft tissue contracture may not have been developed. Therefore, the affectivity of traction and manipulation is being diminished by the time passes after the fracture.^[7,10,14] In our patient group, the operations were performed within 5 hours to 7 days (average 10.7 hours) from admission to the hospital. If a patient has not undergone operation within 7 days after

the initial trauma due to a concomitant disease or other additional pathologies, classic gradual reduction methods should be preferred rather than this method.

One of the most important problems encountered using the fixator during the treatment of a patient's fracture is pin-site infection. Soft tissue irritation resulting from the pushes and tractions of wires and pins frequently facilitates pin-site infections.^[2,14,22] Soft tissue healing is faster in reduced fractures and irritation around pins and wires becomes lower. Thus, as an advantage follow-up control intervals can be in longer periods. In our patient group, the average number of control visits after discharge from hospital was 3.9 (3-7)/times/patient.

In the classical application techniques, reduction is made during or after the application of fixator frames. It requires using more fixator elements which results in a larger and a heavier fixator. Furthermore, radiation exposure is higher during the reduction process. Fixator manipulations during application lead to decreases in the stability of the construct.^[23,24] In our method, fluoroscopy is used only at the reduction stage. There is no need for fluoroscopy, after reduction has been achieved. Thus, in the hinge-fixator technique radiation exposure of surgical team is also reduced. In our patient group, the mean number of fluoroscopy images is 6.4 (4-12) images.

We demonstrate that the hinge-fixator method in the treatment of tibia fractures is fast and easy with a shorter operation time, lesser radiation exposure, shorter hospital stay, longer follow up visit intervals, and a more comfortable treatment period. It also leads to excellent radiologic and clinical outcomes.

Conflicts of interest: The authors did not receive grants or outside funding in support of their research or preparation of this manuscript. They did not receive payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, educational institution, or other charitable or nonprofit organization with which the authors are affiliated or associated.

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KLİNİK ÇALIŞMA - ÖZET

Açık tibia kırıklarının sirküler fiksatorler ile tedavisinde yeni bir uygulama tekniği: Fiksator-menteşe yöntemi

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AMAÇ: Bu çalışmada, sirküler fiksator-menteşe kombinasyonu ile daha kolay ve hızlı fiksator uygulaması sağlayan, klinik ve radyolojik sonuçları geliştiren yeni bir uygulama yöntemi anlatıldı.

GEREÇ VE YÖNTEM: Önerdiğimiz uygulama yöntemi ile 14 tibia kırığı olgusu tedavi edildi. Hastaların 10'u erkek, dördü kadın ve ortalama yaş 41.3 (dağılım, 24-58) yıl idi. Sirküler fiksator menteşe tekniği kullanılarak, öncelikle hızlı anatomik redüksiyon ve geçici kırık stabilizasyonu sağlandı. Skopi kontrolünden sonra fiksator uygulaması tamamlanarak gerçek kırık stabilizasyonu yapıldı. Hastalardan elde edilen veriler ve son kontrollerde alınan klinik ve radyolojik sonuçlar Paley kriterlerine göre değerlendirildi.

BULGULAR: Tüm hastalarda solid osseöz kaynama elde edilerek, ortalama 5.4 (dağılım, 3-8) yıl boyunca takip yapıldı. Son değerlendirmede Paley'e göre radyolojik olarak 2 iyi, 12 mükemmel ve klinik olarak da 13 mükemmel, 1 iyi sonuç elde edildi.

TARTIŞMA: Kırıkların sirküler fiksator-menteşe yöntemi ile tedavisinde hızlı ve kolay bir uygulama imkanı sağlanmaktadır. Bu yöntemde daha kısa cerrahi süresi, daha az radyasyon maruziyeti, daha kısa hastane yatış süreleri ve daha seyrek hastane kontrolleri ile birlikte daha konforlu bir tedavi süreci sağlanmaktadır.

Anahtar sözcükler: Sirküler fiksator; menteşe yöntemi; tibia kırığı.

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