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. [5,4] 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 period, 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.
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. On the plain radiographs, angles between the anatomic axis of the proximal and distal segments were evaluated, while varus-valgus or procurvation-recurrence deformities were recorded. Complications were also recorded according to Paley’s complication classification.

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 hinges (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
was confirmed by fluoroscopy), the screws of the hinge system were tightened. Thus, the fracture was fixated 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](image1.png)

**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](image2.png)

**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 recurrance 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 recurvatum 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. 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. In conservative treatment methods, some of these listed disadvantages can be eliminated, but obtaining good reduction and stable fixation still pose a problem. 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.

There is a general consensus that better reduction result in earlier and stronger union outcomes. 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.

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 diminished by the time passes after the fracture. 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. 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. 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.

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Açık tibia kırıklarının sirküler fiksatörler ile tedavisinde yeni bir uygulama tekniği: Fiksatör-menteşe yöntemi

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AMAC: Bu çalışmada, sirküler fiksatör-menteşe kombinasyonu ile daha kolay ve hızlı fiksatör uygulaması sağlayan, klinik ve radyolojik sonuçların geliştirilip yeni bir uygulama yöntemi anlatılmalıdır.


BULGULAR: Tüm hastalarda solid osseoz kaynama elde edilerek, ortalamada 5.4 (dağılım, 3-8) boyunca takip yapıldı. Son değerlendirme ile Paley’e göre radyolojik olarak 2 iyi, 12 mükemmel ve klinik olarak da 13 mükemmel, 1 iyi sonuç elde edildi.


KLİNİK ÇALIŞMA - ÖZET

ÖZET


