Clinical Experience

Surgical Treatment of Ankle Syndesmosis Injuries with Syndesmosis Elastic Hook

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INTRODUCTION
Distal tibiofibular syndesmosis injuries are usually associated with ankle fractures, especially common in Denis B and C fractures.[1] Syndesmosis is essential for stability of the ankle mortise that is required for weight transmission and walking. The syndesmosis consists of the anteroinferior tibiofibular ligament, posteroinferior tibiofibular ligament, inferior transverse tibiofibular ligament, and interosseous membrane. Internal fixations of the syndesmosis were recommended by most authors to repair the associated ruptured ligaments,[2] which bring about the adverse consequences of limiting the physiological micromovement of the tibiofibular joint to some extent.

To this end, we have designed a syndesmosis elastic hook (SEH) [Figure 1] (Xiamen Double Engine Medical Material Co., Ltd., China), for which we have obtained the national patent (Patent Number: 201220005912.4). The hook is in the form of serpentine semi-ring and made of stainless steel. It passes round the fibula using fork-like pickpocket and it is secured to the tibia by a single 3.5 mm cancellous bone screw passing through the nail hole on the SEH. The elastic hook can not only effectively fix the tibiofibular syndesmosis, but also retain the physiological micromotion of tibiofibular joint. We have performed the biomechanical testing for the SEH, and cyclic axial loadings were applied to specimens with the distal tibiofibular syndesmosis injuries fixing with the SEH at 2, 5, 8, and 12 weeks.[2] With fatigue test, the SEH restored 95% of the distal tibiofibular syndesmosis stability effect.[2] The purpose of this study was to report a new surgical technique for the treatment of ankle fractures together with diastasis of the tibiofibular syndesmosis with SEH and to retrospectively evaluate the outcome of these patients with clinical follow-up.

METHODS
From February 2011 to August 2012, a consecutive series of 29 patients (17 males and 12 females, 13 left legs and 16 right legs, aged 16–49 years, with an average age of 35 years) diagnosed with ankle fracture underwent surgery in our department, which were isolated Weber Type-B or C fractures according to X-ray examination results and the Danis–Weber classification. Eleven patients were injured in traffic accident, seven were injured in sports, five were injured in crush injury, and six in falling injury. All cases were fresh closed ankle fractures with no significant associated injuries. Patients with open fractures, large area of soft tissue injury, and multiple fractures were excluded from the study.

The surgical procedures were performed under spinal anesthesia with the patient in the supine position on the operating table by the same surgeon as soon as soft tissue edema was controlled. Throughout the procedure, we did not use the tourniquet to reduce postoperative swelling of the limb. Prophylactic antibiotic treatment was started preceding 30 min of operation and continued for 24 h postoperatively. Lateral malleolar fractures were approached through a length of 6–8 cm curved incision, and lateral metallic one-third tubular plates were used in fixation of fractures with 3.5 mm

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screws. Three 3.5 mm sized cortical screws were inserted to the proximal of the fracture and four 3.5 mm sized cancellous screws were inserted to the distal of the fracture.

The ankle mortise stability was tested with standard cotton test and lateral rotation stress to the fibula under intraoperative fluoroscopy to clearly identify ligament disruption of the distal tibiofibular syndesmosis. Patients were included in the study only when the radiographic measurements were more than 3.0 mm of widening of the tibiofibular separation space. The syndesmosis was held reduced with a large towel clamp and SEH was placed across syndesmosis from the fibula to the tibia which was secured to the tibia by a 3.5 mm cortical bone screw passed through the 3.5 mm hole in diameter of the hook. The tibiofibular syndesmosis ligaments were not repaired. Once subsequent surgical procedure was completed, the ankle joint stability was tested in all directions.

Postoperatively, patients were immediately immobilized in a below-knee plaster cast for 3 weeks. Early weight bearing was allowed as pain alleviated after 6 weeks, with the use of a nonweight-bearing splint. Clinical and X-ray follow-up were obtained at 3 weeks, 6 weeks, 3 months, 6 months, 1 year, and annual thereafter. Functional outcome of patient was assessed by means of the ankle fracture scoring scale of Olerud and Molander.

RESULTS

The statistical description of patients and clinical follow-up results are depicted in Table 1. Six patients were lost to follow-up before the fracture healed, and the mean duration of follow-up was 3.5 (range 2–6) months. Although there were no complications in these patients, no ankle scores are available for them.

The remaining 23 patients were followed up for at least 12 months, and the average follow-up period was 34 (range 24–48) months. Twenty-one (91.30%) out of 23 patients returned to their original work within 10 (range 8–16) weeks, two patients changed the work immediately after the injury.

The mean ankle score for the remaining 23 patients at their 48 months was 96 points [range 90–100; Table 1]. Based on the cotton test or lateral rotation stress to the fibula, all the 23 patients were followed up with a negative hook test. Patients with low scores were mainly due to the lack of ankle flexion exercise, which led to the stiffness and swelling of ankle joint. Only one patient had none-to-mild occasional pain, which can be alleviated by oral nonsteroidal painkillers.

The follow-up radiograph showed that all ankle fractures had healed in an anatomical position at an average of 5 months (range, 3–6 months), with fracture lines disappearing [Figure 2]. There was no evidence of breakage of SEH, and we removed it in four cases due to strong demand of patients. All patients were routinely given antibiotics postoperative 24 h, and there were no infection complications.

DISCUSSION

Syndesmosis injuries arise in 10–15% of all patients with ankle fractures. Several authors have demonstrated that restoration of the syndesmosis as well as anatomic reduction of any associated fracture of the fibula or the medial malleolus is equally important. The literature showed that widening and chronic instability of the distal tibiofibular syndesmosis have been correlated with poor functional outcomes and the development of osteoarthritis. Therefore, the surgical fixation is usually recommended for the treatment of syndesmotic injuries.

Many surgical methods of fixation have been described to stabilize the syndesmosis in the literature: the syndesmosis elastic hook.
hook,[8] syndesmosis screw,[9] Arthrex’s TightRope,[9] bolt,[10] or bioabsorbable screw,[11] to reduce and hold the syndesmosis in position anatomically until the syndesmosis healing with early fiber formation. However, there is no consensus regarding the most reliable treatment for providing the most effective clinical outcomes.

The ankle syndesmosis is considered as a dynamic fibrous joint. With dorsiflexion of the foot, the distal tibiofibular joint space widens to deepen the ankle mortise to accommodate the wider portion of the trapezoidal talus. This relative motion is very important between the articulating bones for the physiological function of ankle mortise during weight-bearing walking and ankle range of motion. Therefore, combining with clinical considerations, the operative methods for treating syndesmosis injuries through the aforementioned fixations will limit the postoperative motion of the distal tibiofibular joint to some extent, which are thus restricted for the treatment of syndesmosis injuries.

The SEH is designed according to the physiological micro-movement feature of the syndesmosis, including resilient serpentine linker, fork-like pickpocket across the fibula end, and single cancellous screw hole of the distal tibial end, which can not only effectively fix the distal injured tibiofibular syndesmosis, but also retain the micro-movable feature of it. There is no need to remove the SEH prior to walking, and we have conducted biomechanical testing to support the clinical use.

In this series of patients, some of the complications such as loosening, breakage, and migration have not been observed. Only five patients felt uncomfortable after we removed the fixations. The technique described in this study fulfills the principles of biological fixation and allows early functional exercises, which is a simple and quick operative procedure providing reliable syndesmotic reduction.

In conclusion, the use of SEH of fixation of syndesmosis can provide stable fixation with a very low rate of complications and achieve satisfactory functional outcome. We believe that it is one of the suitable options for treating ankle syndesmosis injuries. However, it is necessary to continue to follow up on the clinical effects of this fixation method.

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**Conflicts of interest**

There are no conflicts of interest.

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**Table 1: Data of the 23 patients**

| Case | Gender, age (years) | Side | Danis–Weber classification | Duration of follow-up (months) | Olerud score (points) | Complications |
|------|---------------------|------|-----------------------------|-------------------------------|----------------------|---------------|
| 1    | Male, 23            | Right| Type-C                      | 24                            | 90                   | None          |
| 2    | Female, 43          | Left | Type-C                      | 26                            | 95                   | None          |
| 3    | Male, 35            | Right| Type-B                      | 30                            | 95                   | None          |
| 4    | Male, 37            | Right| Type-B                      | 36                            | 100                  | None          |
| 5    | Female, 16          | Right| Type-C                      | 38                            | 95                   | None          |
| 6    | Male, 22            | Left | Type-C                      | 40                            | 100                  | None          |
| 7    | Male, 49            | Right| Type-B                      | 48                            | 100                  | None          |
| 8    | Female, 32          | Left | Type-C                      | 28                            | 95                   | None          |
| 9    | Male, 37            | Right| Type-C                      | 27                            | 95                   | None          |
| 10   | Male, 28            | Left | Type-C                      | 31                            | 90                   | None          |
| 11   | Female, 45          | Right| Type-C                      | 32                            | 100                  | None          |
| 12   | Female, 28          | Right| Type-C                      | 40                            | 90                   | None          |
| 13   | Female, 26          | Right| Type-B                      | 38                            | 100                  | None          |
| 14   | Male, 33            | Right| Type-B                      | 33                            | 95                   | None          |
| 15   | Male, 38            | Left | Type-C                      | 34                            | 95                   | None          |
| 16   | Male, 25            | Right| Type-C                      | 25                            | 95                   | None          |
| 17   | Female, 27          | Left | Type-C                      | 26                            | 100                  | None          |
| 18   | Male, 31            | Left | Type-C                      | 28                            | 100                  | None          |
| 19   | Male, 29            | Left | Type-C                      | 30                            | 95                   | None          |
| 20   | Female, 33          | Right| Type-B                      | 32                            | 95                   | None          |
| 21   | Male, 38            | Left | Type-B                      | 48                            | 95                   | None          |
| 22   | Female, 43          | Left | Type-C                      | 46                            | 95                   | None          |
| 23   | Female, 41          | Left | Type-C                      | 42                            | 100                  | None          |
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