Prevalence of knee stiffness after arthroscopic bone suture fixation of tibial spine avulsion fractures in adults

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ABSTRACT

Background: Tibial spine avulsion fractures (TSAFs) occur chiefly in adolescents. Few published data are available on outcomes after arthroscopic surgical treatment of TSAFs in adults.

Objectives: To evaluate outcomes of consecutive patients with TSAFs managed by arthroscopic bone suture followed by a standardised non-aggressive rehabilitation programme.

Hypothesis: Arthroscopic bone suture followed by non-aggressive rehabilitation therapy reliably produces satisfactory outcomes in adults with TSAF.

Methods: Thirteen adults were included. Outcomes were evaluated based on the Tegner score, International Knee Documentation Committee (IKDC) score, anterior-posterior knee laxity, passive and active motion ranges, and radiological appearance.

Results: After a mean follow-up of 41 ± 27 months (12–94 months), all 13 patients had healed fractures without secondary displacement. No patient had knee instability. Post-operative stiffness was noted in 5 patients (2 with complex regional pain syndrome and 3 with extension lag), 1 of whom required surgical release. The mean IKDC score was 91.3 ± 11.7. The mean Tegner score was 5.46 ± 1.37 compared to 6.38 ± 0.70 before surgery. Mean tibial translation (measured using the Rolimeter) was 1.09 ± 1.22 mm, compared to 5.9 ± 1.85 mm before surgery.

Conclusion: The outcomes reported here support the reliability of arthroscopic bone suture for TSAF fixation. Nevertheless, a substantial proportion of patients experienced post-operative stiffness, whose contributory factors may include stunning of the quadriceps due to the short time from injury to surgery and the use of a gentle rehabilitation programme.

Level of evidence: IV, retrospective study of treatment outcomes.

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Tibial spine avulsion fractures (TSAFs) are uncommon injuries with an annual incidence of about 1/10^5 [1]. The mechanism may be either a direct impact or deceleration during sports such as football or skiing [2]. Adolescents are predominantly affected, and few published studies address the arthroscopic surgical treatment of TSAFs in adults [3–5].

The objective of this study was to evaluate the functional outcomes after TSAF treatment using arthroscopic non-absorbable bone suture followed by a standardised, non-aggressive, specific rehabilitation programme. The working hypothesis was that this management strategy reliably produced satisfactory outcomes in adults.

1. Material and methods

1.1. Patients

The study inclusion criteria were as follows: displaced TSAF type II/III/IV according to the modified Meyers and McKeever classification [6], radiographic appearance indicating fully closed physes, and a follow-up since surgery of at least 6 months. Between January 2007 and November 2013, 13 patients meeting these criteria were included. Two senior surgeons performed the arthroscopic procedures.

1.2. Assessments

The pre-operative work-up included anterior-posterior and lateral radiographs of the knee and either computed tomography (CT) or magnetic resonance imaging (MRI). The Tegner score, IKDC score,
and laxity measured using the Rolimeter (Aircast, DJO Global, Vista, CA, USA) were recorded before and after surgery. A goniometer was used to measure motion ranges. Fracture healing was assessed on radiographs taken 3 months after surgery.

1.3. Operative technique

Mean time from injury to surgery was 19.1 days (5–65 days). In all 13 patients, a surgical technique similar to that described by Berg [7] was used (Fig. 1). After reduction, the fracture was fixed provisionally using two K-wires measuring 2 mm in diameter and inserted percutaneously. A ligamentoplasty aiming device was inserted under arthroscopic guidance and used to drill two tunnels, each 2.7 mm in diameter, whose exit sites were located medial and lateral to the fracture, respectively.

A dedicated 45° hook (SutureLasso™, Arthrex, Naples, FL, USA) loaded with non-absorbable suture (Fiberwire, Arthrex; #2) was inserted through the antero-medial port, passed through the

Fig. 1. Operative technique for arthroscopic reduction and bone suture of tibial spine avulsion fractures. A, B: appearance of the fracture; C, D: the reduced fragment is fixed temporarily using two U-shaped sutures (one positioned anteriorly and the other posteriorly) passed through the anterior cruciate ligament; E, F: passers are then used to thread the sutures through the bone tunnels; G, H: Final appearance.
posterior part of the anterior cruciate ligament (ACL), and removed through the antero-lateral port. This procedure was repeated with the hook in a more anterior position relative to the tibial footprint of the ACL. The sutures were then threaded through the tibial tunnels. The knee was fully extended to assess for impingement. The sutures were tensioned then tied to the tibia with the knee flexed at 30°. The two K-wires were removed.

1.4. Rehabilitation programme

The same rehabilitation programme was used in all patients. The programme included stimulation and strengthening of the quadriceps and hamstrings to protect the bone suture and a prompt but gradual return to weight bearing. A splint that immobilised the knee in full extension was worn day and night for 3 weeks. The splint was removed only for the rehabilitation sessions. Ambulation with a cane was started on the first post-operative day. During the fourth post-operative week, use of the splint was discontinued and gait training with two parallel canes was started. From the eighth week onwards, the patients walked with no splint and no canes.

Passive knee mobilisation between 0° and 60° was started immediately after surgery. The range of flexion was increased gradually to 90–95° by 6 weeks and 120° by 12 weeks.

Electrostimulation and biofeedback were used for the quadriceps. Active quadriceps locking exercises were started during the second week in combination with closed-chain exercises to strengthen the quadriceps and hamstrings.

2. Results

Thirteen patients were included. They had a mean age of 31.5 years (16–51 years) and a mean follow-up of 43.4 months (12.8–94.4 months). The TSAF type was II in 5 patients, III in 4 patients, and IV in 4 patients. Complete follow-up data were available for all 13 patients. One patient had a Segond fracture (Fig. 2) and another a grade II injury to the medial collateral ligament, which was managed conservatively (Table 1).

Fig. 2. Thirty-two-year-old male patient with post-operative stiffness; A, B: pre-operative computed tomography: tibial spine avulsion fracture type IV (white arrow) and Segond fracture (white circle); C, D: magnetic resonance imaging (MRI) 6 months after surgery: the tibial spine avulsion fracture and Segond fracture are fully healed. The patient has a 10° extension lag. There is no anterior impingement on the roof of the intercondylar notch. E: arthroscopic appearance during surgical release performed 9 months after treatment of the fractures; F: satisfactory appearance during tensioning of the anterior cruciate ligament. In addition to anterior joint release, release of the posterior capsule was required to restore full knee extension.
Table 1

Details about the 13 patients included in the study.

<table>
<thead>
<tr>
<th>Patient #</th>
<th>Gender</th>
<th>Age (y)</th>
<th>Other injuries</th>
<th>Injury-to-surgery time (days)</th>
<th>Follow-up (months)</th>
<th>IKDC Subjective Form</th>
<th>Tegner Pre-op</th>
<th>Tegner Post-op</th>
<th>Post-op Rötlimeter (mm)</th>
<th>IKDC Objective Form</th>
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<td>6</td>
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<td>2</td>
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<tr>
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<td>F</td>
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<td>36</td>
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<td>98</td>
<td>6</td>
<td>6</td>
<td>1</td>
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</tr>
</tbody>
</table>
| 5         | F      | 33      | No             | 23                         | 45                | 97                    | 6             | 5             | 1                       | B                   | Extension lag (5’)
| 6         | M      | 28      | No             | 10                         | 68                | 99                    | 7             | 7             | 1                       | A                   | None          |
| 7         | M      | 25      | No             | 65                         | 82.7              | 98                    | 6             | 6             | 0                       | A                   | None          |
| 8         | M      | 16      | No             | 5                          | 28.4              | 98                    | 7             | 7             | 0                       | A                   | None          |
| 9         | M      | 44      | No             | 7                          | 21.9              | 99                    | 6             | 5             | 4                       | A                   | None          |
| 10        | M      | 32      | Second fracture | 11                        | 22.5              | 84                    | 6             | 6             | 2                       | C                   | Extension lag (10’); requiring surgical release |
| 11        | F      | 32      | No             | 15                         | 13.4              | 81                    | 6             | 3             | 4                       | B                   | MCL injury |
| 12        | F      | 18      | MCL            | 12                         | 12.8              | 67                    | 6             | 4             | 0                       | B                   | MCL injury |
| 13        | F      | 51      | No             | 38                         | 14.2              | 71                    | 6             | 3             | 0                       | D                   | CRPS          |

MCL: medial collateral ligament; CRPS: complex regional pain syndrome.

2.1. Stiffness

Knee stiffness was noted post-operatively in 5 (38%) patients. Among them, 2 had complex regional pain syndrome, which resolved in 1 patient (#3) after conservative treatment and is improving in the other (#13). The remaining 3 patients had residual fixed flexion. The extension lag was only 5° in 2 patients (#5 and #11) and had no adverse effect on knee function. The third patient (#10) had a 10° extension lag due to arthrofibrosis and required surgical release after 10 months. Arthroscopy in this patient showed no cyclops lesion or impingement on the roof of the intercondylar notch (Fig. 2). After anterior joint release, the intraoperative assessment showed persistence of a 10° extension lag. Posterior release of the joint capsule through two retroligamentous approaches was needed to restore full knee extension. At last follow-up, the extension lag was only 3° and had no impact on function.

In the overall population, at last follow-up the extension lag relative to the contralateral knee was 0.8°.

2.2. Functional and radiographic outcomes

In all 13 patients, the radiographs taken after 3 months showed healing of the fracture in the anatomic position with no secondary displacement.

The mean Tegner score improved from 6.3 ± 0.6 pre-operatively to 5.4 ± 1.7 at last follow-up. The IKDC score was 91.3 ± 11.5 at last follow-up. The patient with a concomitant injury to the medial collateral ligament had residual functional impairments with an IKDC score of 67.

Anterior tibial laxity decreased from 5.9 ± 1.85 pre-operatively to 1.2 ± 1.4 post-operatively. The pivot shift test was negative in all 13 patients. None of the patients had functional knee instability.

At last follow-up, none of the knees exhibited clinical or radiological evidence of degenerative joint disease.

3. Discussion

Encouraging functional outcomes were documented in this case-series study. Our results in terms of knee stability are comparable to those obtained by others [3,8–12]. Nevertheless, knee stiffness was noted in a substantial proportion of patients. In most cases, however, conservative treatment was successful in restoring satisfactory motion range, and further surgery was rarely needed.

Our hypothesis is confirmed inasmuch as fracture healing without secondary displacement was achieved consistently. No patients had subjective or objective evidence of knee instability or laxity. The clinical score values were good to excellent and were comparable to those reported previously [8,13–15]. In contrast, our hypothesis was refuted in terms of post-operative stiffness.

Published data on the arthroscopic management and functional outcomes of TSAFs are less abundant for adults than for adolescents [2,4,6]. Bone suture has been found superior over screw fixation [16]. The two most common complications after TSAF are residual laxity (associated with non-operative management or technical errors during surgery) and post-operative stiffness [17–19]. Thus, in our study, 38% of patients had knee stiffness, at least temporarily, after surgery. Liljeros et al. reported an extension lag in 4/13 (31%) children and adolescents after TSAF fixation using bioabsorbable nails [20]. A study of 12 adults managed by Koukoulas et al. [3] using a technique similar to ours showed an extension lag in 5 (41%) patients.

Favre et al. [21] used the Tightrope® device (Arthrex) to treat 8 adults with TSAFs and noted post-operative stiffness in 3 (38%) cases. After TSAF fixation with folded K-wires, Bonin et al. [22] found stiffness in 40% of patients. Of 17 adults with TSAFs managed by Montgomery et al. [17] using arthroscopic bone suture, 9 (53%) had post-operative stiffness.

Stiffness of the knee is a focus of considerable concern, given its adverse impact on knee function [23]. Residual arthrofibrosis is a multifactorial condition related to age, gender, genetic susceptibility, time from injury to surgery, and prolonged immobilisation. Noyes et al. [24] reported that arthrofibrosis is initially a transient abnormality and that early mobilisation combined with aggressive rehabilitation therapy may prevent progression to permanent arthrofibrosis. Several factors may contribute to post-operative stiffness. First, when performed promptly after the injury, surgery occurs in an unprepared knee with a pre-operative extension deficit, bone contusion, and a weak quadriceps. Second, prolonged post-operative immobilisation increases the risk of stiffness. Finally, an unduly cautious rehabilitation programme may result in failure to restore full motion range [25,26]. TSAFs are due to the same mechanism that causes ACL injuries. As a result, the complications seen during the post-operative management of TSAFs are comparable to those seen after ACL repair.

Thus, an ACL tear results in the activation of complex neurovascular processes that limit anterior tibial translation by inducing inhibitory reflexes at the quadriceps or co-contraction of the hamstrings and quadriceps [27]. These mechanisms may alter the...
afferent signals sent to the nervous system, thereby inhibiting impulse transmission from the motor neurons to the quadriceps and depressing voluntary muscle contraction [28,29]. The shorter time from injury to surgery in TSAFs compared to ACL tears may contribute to a higher rate of arthrofibrosis in TSAFs, although our data cannot confirm this possibility. In a few studies of ACL tears, an injury-to-surgery time longer than 3 weeks was associated with a lower frequency of arthrofibrosis [5,30]. With TSAFs, reduction is more difficult when surgery is delayed. Nevertheless, a strategy similar to that used for ACL repair with a waiting time of at least 10 days and aggressive pre-operative mobilisation [31] may deserve evaluation.

Furthermore, the use of splints before or after surgery does not seem required. In contrast, full knee extension and quadriceps activation must be obtained pre-operatively. Thus, one avenue of research is whether delayed surgery combined with early aggressive rehabilitation before and after surgery benefits full motion range recovery after surgery.

The limitations of our study include the retrospective design, small sample size inherent in the low prevalence of TSAFs in adults, variability in time from injury to surgery, and absence of comparisons to patient groups managed with different rehabilitation programmes.

4. Conclusion

In adults with TSAFs, arthroscopic bone suture provides encouraging results in terms of fracture healing, knee stability, and functional scores. The substantial proportion of patients with post-operative knee stiffness may be ascribable to the short injury-to-surgery time with quadricep stunning at the time of surgery, perhaps with a cautious rehabilitation programme as an additional risk factor.

Disclosure of interest

The authors declare that they have no competing interest.

References