

# Interference Screw Divergence in Endoscopic Anterior Cruciate Ligament Reconstruction

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**Summary:** Interference screws are commonly used for graft fixation in bone-tendon-bone patellar tendon anterior cruciate ligament (ACL) reconstruction. The clinical significance of graft screw divergence has not been well studied. This report retrospectively reviews our initial experience in 73 consecutive endoscopic (single-incision) ACL reconstructions using interference screw fixation. Femoral divergence occurred more frequently in the lateral plane (29%) than the anteroposterior (AP) plane (15%). No early graft failures were noted clinically or by KT-1000 arthrometer testing. If properly tested at the time of operation, it does not appear that divergence of femoral screws  $< 30^\circ$  leads to early clinical failure in endoscopic ACL reconstruction. We propose that stresses on the graft-screw-tunnel construct will concentrate distally when placed in a divergent fashion, resulting in a wedge effect. No changes in early range of motion protocols or rehabilitation are recommended if screw divergence is noted and provided intraoperative stability is noted. **Key Words:** ACL—Graft fixation—Interference screw fixation.

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Multiple methods of graft fixation have been popularized for patellar bone-tendon-bone grafts used in anterior cruciate ligament (ACL) reconstruction. These include staple, sutures over buttons, sutures around a screw and post, screws through bone graft, and interference screws. Lambert is credited with the initial report on the use of interference fixation using 6.5 A/O screws (Synthes, Paoli, PA).<sup>1</sup> Subsequently, Kurosaka et al. tested grafts fixated by various techniques and noted that a custom 9-mm interference screw had a significantly higher tensile strength to failure.<sup>2</sup> Butler<sup>3</sup> affirmed this work and additionally noted that graft fixation technique is one of multiple factors related to the ultimate failure strength of ACL graft constructs. Other factors include bone quality, bone

graft size and length, gap space interval, screw diameter, and screw length.<sup>3</sup> The rigid fixation afforded by interference screw fixation is an important factor in early motion, early weight bearing, and accelerated rehabilitation programs. Potential problems with interference screw use, including tunnel-screw divergence, have been reported.<sup>4-7</sup> Few studies have addressed the clinical significance of graft-screw divergence.<sup>8</sup> We hypothesized that early graft failure should occur within 6 months postoperatively if inadequate bone plug fixation occurred secondary to screw divergence. This retrospective study reviews our initial endoscopic bone-tendon-bone patellar tendon ACL reconstruction technique. An attempt to correlate interference screw divergence with early clinical failures, based on serial physical examination and KT-1000 testing, was performed.

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## MATERIALS AND METHODS

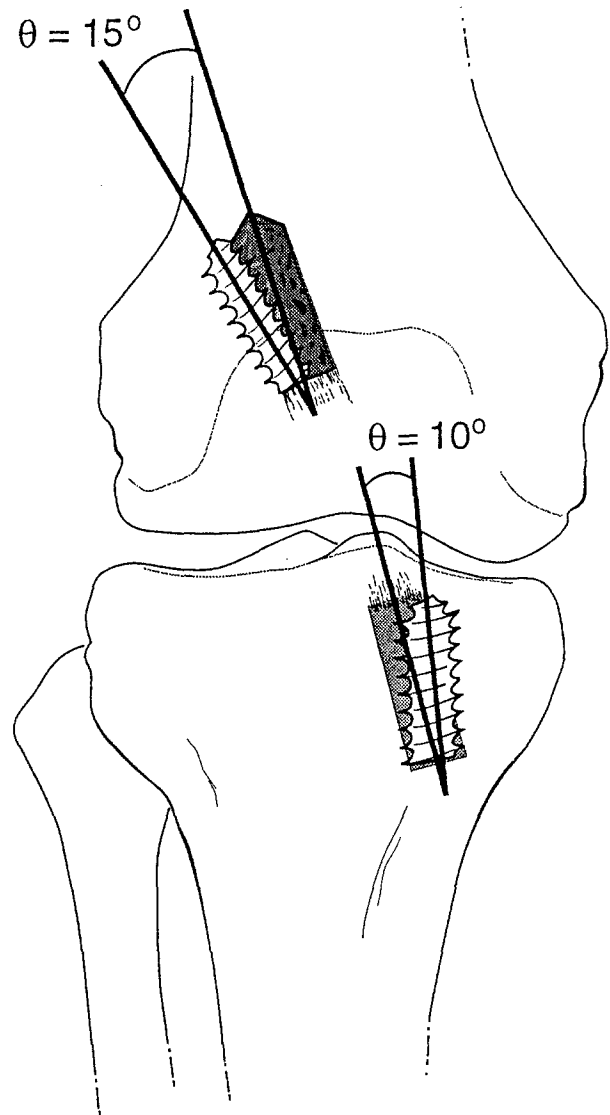
A retrospective analysis of 73 consecutive endoscopic patellar bone-tendon-bone ACL reconstructions

performed between October 1991 and December 1992 was performed. This represented the initial experience of one surgeon (B.R.B.) over a 14-month period. Inclusionary criteria for surgical reconstruction included recurrent knee instability secondary to ACL insufficiency or the desire to participate in sporting activity unbraced. Exclusionary criteria included previous contralateral ACL reconstruction or insufficiency or combined ipsilateral multiligament repair. Preoperative clinical evaluation consisted of anterior drawer, Lachman, and pivot shift tests. The anterior drawer and Lachman tests were graded 1+ (1 to 5 mm), 2+ (6 to 10 mm), or 3+ (>10 mm) compared with the opposite normal knee. The pivot shift phenomenon was graded as 1+ (slip), 2+ (jump), or 3+ (transient lock). All patients had evidence of an abnormal pivot shift phenomenon when examined under anesthesia. Additionally, KT-1000 (Medimetric, San Diego, CA) testing at 15 pounds, 20 pounds, and maximum manual were performed, deriving the 20-pound difference, maximum manual difference, and the compliance index as described by Daniel et al.,<sup>9</sup> and Bach et al.<sup>10</sup> Testing was performed by an individual experienced with the device since 1986. An arthrometric failure was defined as a postoperative maximum manual side-to-side difference  $\geq 5$  mm. A clinical failure was defined as demonstration of a pivot shift phenomenon regardless of the grade.

All patients had a postoperative knee radiograph obtained at the first postoperative visit (anteroposterior [AP] and lateral views). The long axes of the bone graft and of the interference screw were each determined, and the angle between these two was measured (Figs 1, 2). This measurement was repeated for femoral and tibial screws on the AP and lateral views (four measurements). Radiographs were measured twice in a blinded fashion by the author (B.P.J.). On all films,  $5^\circ$  was considered the degree of accuracy, similar to techniques used for evaluating spine radiographs. Postoperative follow-up consisted of routine clinical examinations and KT-1000 measurements at 6-week intervals until 6 months postoperatively. At each visit, the clinical examination and KT-1000 testing previously described were performed. It should be noted that by design this study reviewed the first 6 months postoperatively only, because graft failures caused by decreased interface fixation from screw divergence should occur during the period before bone plug-tunnel healing.

### Study Group

The study group consisted of 49 men or boys and 24 women or girls with a mean age of 29 years (range, 15

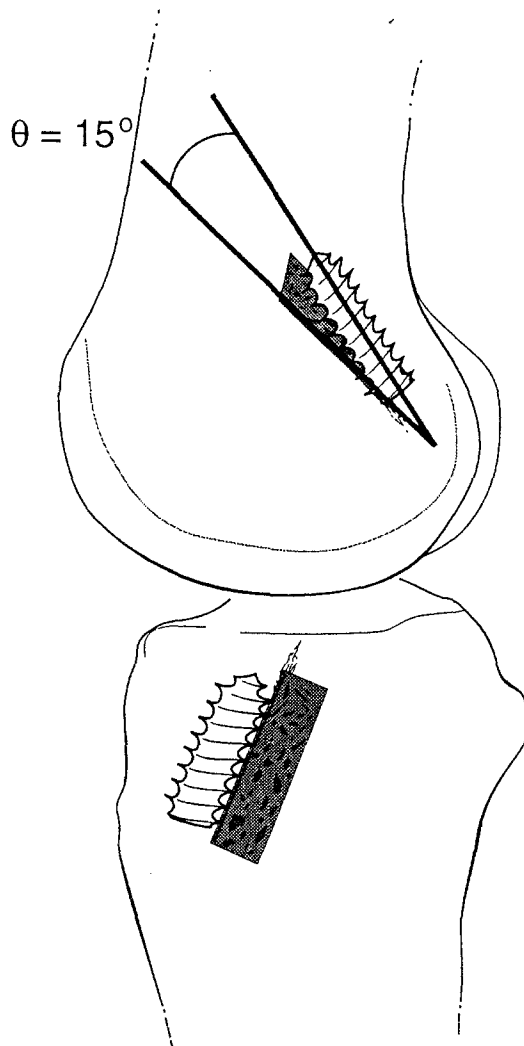


**FIG 1.** This anteroposterior schematic illustration depicts the measurement technique employed. The angle created by the intersection of the long axis of the bone plug and screw were measured to determine the divergence angle ( $\theta$ ).

to 56). There was an equal distribution of right and left knees. The mean interval to reconstruction was 28 months (range, 3 weeks to 20 years). Fifty-five patients received autografts, and three received nonirradiated fresh frozen patellar tendon allografts. There was a 45% incidence of associated intraarticular pathology (meniscal tears, chondromalacia, chondral fracture, etc.).

### Surgical Technique

All patients underwent single-incision endoscopic ACL reconstruction using an identical technique by one surgeon (B.R.B.), as previously reported by Hardin



**FIG 2.** This lateral schematic view demonstrates the measurement technique as described in Fig 1.

et al.<sup>11</sup> In this technique, the femoral tunnel is drilled to the size of the bone plug (10 mm), and the graft is pushed up into the previously drilled blind-end femoral tunnel. Using an accessory medial portal under direct arthroscopic vision, a 14-inch Nitenol (Linovatec Inc, Largo, FL) guide wire is preliminarily positioned, the knee is further flexed (approximately 110°), and the pin advanced in the femoral graft tunnel interface, thus minimizing the likelihood of divergent screw placement. After this, the knee was cycled multiple times and the fixation interface reexamined. A “rock” test was performed applying a load to the tibial bone plug sutures adequate to “rock” the patient on the operating table. The graft fixation interface was reevaluated for any change in fixation.

### Postoperative Treatment

An identical postoperative protocol was used for this study group, consisting of cryotherapy, an intraarticular hemovac drain for 24 hours, continuous passive motion while hospitalized, and a drop-lock postoperative knee brace. All patients started physical therapy on the first postoperative day and followed an aggressive physical therapy protocol as popularized by Shelbourne and Nitz.<sup>12</sup> Weight bearing in extension and range of motion were initiated immediately. Crutches were used only as needed, and patients were allowed to return to sports at 6 months.

### STATISTICS

Results were analyzed using SPSS (SPSS, Chicago, IL) statistical package for mean, range, and standard deviation. Additionally, the clinical and KT-1000 data were compared with the radiographic divergence angles and analyzed for significance using both the chi-square test and the Mann-Whitney rank sum test. Statistical significance was defined as  $P < .05$ .

### RESULTS

#### Radiographic

Sixty-three percent of patients had parallel placement of interference screws on both AP and lateral femoral radiographs. Eleven percent of all patients had divergence of the interference screw documented on both the AP and lateral radiographs. There was a 15% incidence of AP plane femoral divergence (range, 0° to 23°; mean, 2.0°), with no cases having divergence greater than 30°. Lateral femoral divergence occurred in 29% of patients (range, 0° to 36°; mean, 5°) and was the most common finding. Six percent of all patients had lateral femoral divergence of greater than 30°.

Seventy-seven percent of patients had parallel placement of interference screws on both AP and lateral tibial radiographs. There was a 23% incidence of AP plane tibial divergence (range, 0° to 17°; mean, 1°) and a 22% incidence of lateral plane tibial divergence (range, 0° to 18°; mean, 1°).

#### Clinical Examination

Ninety-four percent of all preoperative Lachman examinations under anesthesia were graded 2+ (range, 1+ to 3+; mean, 1.9). The anterior drawer was 2+ or greater in 16% of patients, and seven exhibited a negative anterior drawer (mean, 1.1). The pivot shift phe-

nomenon was 2+ or greater in 74% of patients (mean, 1.9).

At 6 weeks postoperatively, 7 of the 73 patients were noted to have a +1 Lachman examination with a firm endpoint, none having greater than 1+. Two patients had an anterior drawer of 1+, and no patients had a pivot shift.

At 6 months postoperatively, 12 patients had a 1+ Lachman and 1 patient had a 2+. Three patients had a 1+ anterior drawer, and no patients exhibited a pivot shift.

At last follow-up, all patients expressed satisfaction with their current short-term results. No reoperations were required for knee flexion contractures, indicating recovery of full extension as determined by prone heel height comparisons.

### KT-1000 Results

The preoperative absolute maximum manual was  $>10$  mm in 70% of patients. The preoperative maximum manual difference was  $\leq 3$  mm in 29% of patients, 3 to 5 mm in 16%, and  $>5$  mm in 55% of patients.

At 6 weeks postoperatively, no patients had an absolute maximum manual  $> 10$  mm or maximum manual difference  $> 3$  mm.

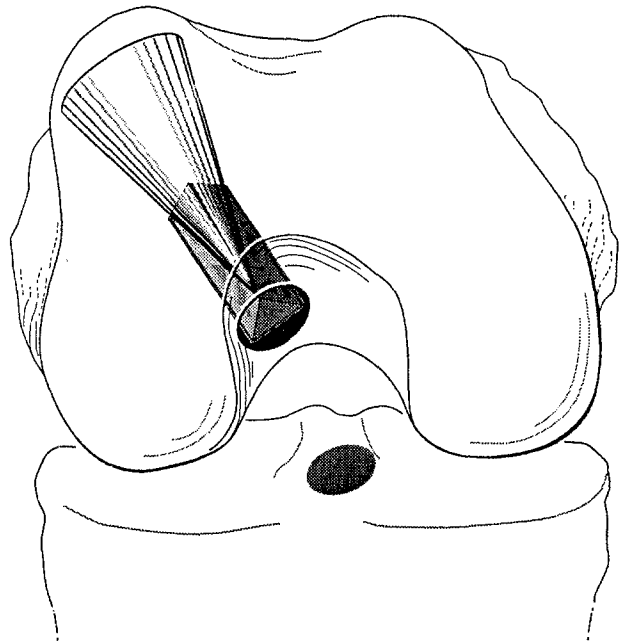
At 6 months postoperatively, the absolute maximum manual was  $>10$  mm in two patients. The maximum manual difference was  $\leq 3$  mm in 90% and 3 to 5 mm in 10%. In no case was the maximum manual difference  $> 5$  mm.

### Statistical Analysis

No significance was found on both chi-square and Mann-Whitney testing when comparing the results of KT-1000 and clinical examination with the amount of femoral or tibial screw divergence in any plane.

## DISCUSSION

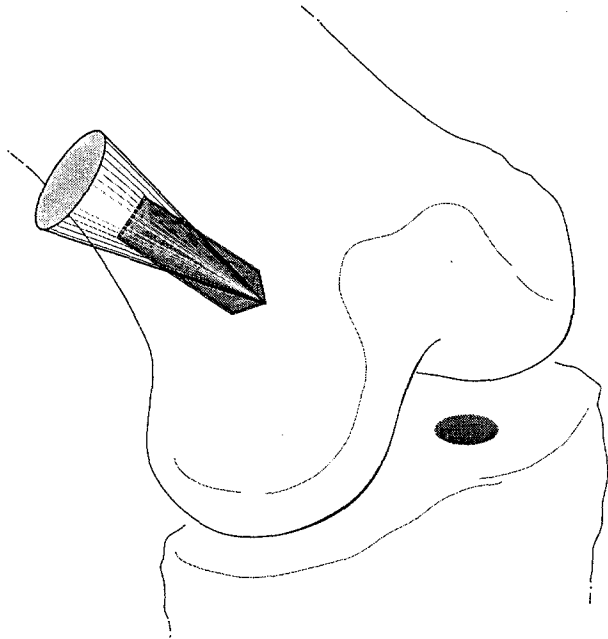
Most of the literature reported regarding interference screw divergence have been biomechanical porcine, bovine, or human cadaver studies.<sup>13-18</sup> There is little information regarding the clinical significance of divergence. Lemos et al. reviewed their incidence of interference screw divergence comparing two-incision and endoscopic procedures<sup>19</sup> and noted a 36% incidence of femoral screw divergence, a rate similar to ours, with an endoscopic technique. Early or delayed failure rates were not discussed. While reviewing the fixation strengths of patellar-tendon-bone grafts, Matthews et al.<sup>20</sup> commented on three divergent interfer-



**FIG 3.** The “funnel” and “wedge” concepts can be conceptualized by this illustration and Fig 4. One must understand that the screw may diverge in more than one plane. The screw, if placed divergently, may act as a wedge, because the graft plug would be pulled *toward* the screw with the endoscopic technique. Screw divergence in the two-incision technique may be more problematic because the bone plug would be pulled *away* from the screw.

ence screws, each of which failed to achieve fixation. Although the degree of divergence was not reported, the importance of recognition of such a problem was stressed.<sup>20</sup> Fulkerson et al. reported Materials Testing System testing of interference screw fixation in porcine knees with divergence of  $0^\circ$ ,  $15^\circ$ , and  $30^\circ$ . In this study, the author compared tensile load with failure for both endoscopic and two-incision techniques. They found that a significant loss of fixation occurred with divergence of  $>30^\circ$  using either technique and noted that this loss of fixation was significantly less in the endoscopic procedure<sup>21</sup> than in the outside-in technique. Lemos et al. recently reported in a bovine model that endoscopic fixation with divergence of  $15^\circ$  did not affect fixation characteristics.<sup>22</sup> We believe this is because, in an endoscopic reconstruction, applied stress would have to overcome the fixation at the distalmost point of the graft-screw-tunnel construct. This represents the area of best fixation, or the “apex” of the divergent angle. In the two-incision technique, the opposite is true with the more divergent region based distally. This idea could be likened to a “funnel” or “wedge” effect (Figs 3, 4).

During endoscopic ACL reconstruction, great care



**FIG 4.** This oblique-lateral view further illustrates the “wedge” or “funnel” concept of screw divergence.

is taken to assure proper positioning and fixation of interference screws. The “rock test” is an additional method of assessing femoral graft fixation. We also advocate and strive for parallel placement of interference screws in all planes. Parallel placement is probably more critical on the tibial side because fixation characteristics are superior on the femoral side and an outside-in screw fixation does not provide a “wedge” effect. When noted to be stable intraoperatively, we have not observed a correlation between femoral interference screw divergence and early clinical failures. Thus, we believe that postoperative changes in bracing, weight bearing, or rehabilitation are unnecessary. An ongoing study continues to monitor these patients.

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