Original

Analysis of Failed Cases of Anterior Cruciate Ligament Reconstruction of the Knee with the Bone-Tendon-Bone Method

Keizo SAKAMOTO, Ikufumi YAMADA, Shoichi TEZUKA,
Yosisada SATO, Toshiyuki YOSHIZAWA and Etsuo FUJIMAKI

Abstract : Fifty-one anterior cruciate ligament reconstructions were performed using the bone-tendon-bone method from April 1991 through March 1996. In these 51 cases floor plasty was not performed in 23 cases, of which 12 cases were judged to be failed ACL reconstructions because of instability of 3 mm or greater relative to the healthy knee and confirmation of rupture with arthroscopy. These 12 cases of failed reconstruction (in 2 men and 10 women) were 6 cases of femoral tunnel (notch), 1 case of femur-side K-screw tip, 3 cases that can be considered tibia tunnel remodeling, and 2 cases that can be attributed to the tibia-side K-screw.

To prevent these failures measures, such as thorough formation of the notch, posteriorly shifting the opening of the tibial articular facet tunnel hole, implementing floor plasty, and development of a non-tapered interference screw, should be considered.

Key words : anterior cruciate ligament, bone-tendon-bone, reconstruction, failed cases

Introduction

The patellar bone-tendon-bone (BTB) method is the standard method for reconstructing the anterior cruciate ligaments (ACL). To investigate the cause of BTB reconstruction failure, we analyzed cases in which reconstruction had failed.

Subjects and Methods

We have been performing the BTB method with the interference screw¹⁾ (K-screw) in cases of ACL insufficiency since April 1991. By March 1996, we had performed the procedure on 27 male and 24 female patients. In 23 of these patients tibia floor (plateau) plasty²⁾ was not performed. These 23 patients were re-examined when the screws were removed; in 14 patients ACL reconstruction was judged, on the basis of clinical evaluations of knee instability, to have failed in these cases, the details of the surgical procedure, the postoperative course, and X-ray images were retrospectively analyzed, in conjunction with a search for an improved method.

The KT-2000 (Med Metric Corp., San Diego, Ca, U.S.A.) and Telos SE (Telos Japan,

Table 1. Estimation

Tibial tunnel Distance from the anterior aspect of the tibia plateau	Arthroscopic		
	Excellent	Good	Poor
< 15mm		2	7
16~19mm	1	6	4
>20mm	2	2	1
Femoral tunnel			
12~1 o'clock	4	7	8
other	1	1	4

ACL Excellent : Good tension and covered with synovium
 Good : Good tension, without synovium
 Poor : Bad tension, without synovium

Tokyo) were used to examine the stability of the knee. If the difference between the injured side and the healthy side was 3 mm or more or if a tear (including partial tearing) or extension of the reconstructed ACL was found with arthroscopy at screw removal at least 1 year after surgery reconstruction was judged to have failed, regardless of whether a synovial membrane covered the reconstructed ACL.

Case

A total of 57 ACL reconstructions were performed from April 1991 through March 1996 : 51 cases of BTB, 3 cases of semitendinosus or semitendinosus and gracilis grafts, and 3 cases in which the Leeds-Keio artificial ligament was used. For this study, we analyzed BTB reconstructions performed before March 1993 in which a tibia floor (plateau) plasty²⁾ groove was made from the opening in the articular facet of the tibial tunnel toward the back. Of the 23 patients, 10 were men (average age, 25.2 years) and 13 were women (average age, 30.4 years). The right knee was involved in 12 cases and the left knee in 11 cases. The causes of ACL injury were sports-related in 20 cases, traffic accidents in 2 cases, and unknown in 1 case.

Result

On the basis of instability (a difference of 3 mm or more between the injured and healthy knees) and re-examination with arthroscopy, ACL reconstruction was judged to be unsatisfactory in 12 cases. Two of the cases were in men (20 % ; average age, 25.5 years) and 10 cases were in women (77 % ; average age, 30.1 years). The average time since surgery in these cases was 25 months.

The damaged portion or abnormality in cases with unsatisfactory results included the femoral tunnel (notch) in 6 cases, the femur-side K-screw tip in 1 case, tibial impingement in 3 cases, and tibial tunnel or tibian-side K-screw in 2 cases.

Table 1 summarizes the observations in 25 BTB cases that were re-examined with arthroscopy when the pins were removed, regardless of whether floor plasty²⁾ was performed. In nine cases, the separation from the front surface of the tibia to the center of the tibial tunnel was 15 mm or less. Of these nine cases, reconstruction failed in seven

(78 %). The distance to the center of the tibial tunnel was between 16 and 19 mm in 11 cases; findings on arthroscopy were “excellent” in 1 case, “good” in 6, and “poor” in 4 (36 %). Of the five cases with a distance of 20 mm or more, reconstruction failed in one (20 %). In 19 cases, the position of the center of the femoral tunnel was considered to be “over the top,” i.e., between the 11 and 1 o’clock positions. Results in these cases, as judged with arthroscopy, were “excellent” in 4, “good” in 7, and “poor” in 8 (42 %). Of the remaining six cases in which the femoral tunnel had been established outside the region described above, 4 (67 %) were judged as failures.

Of the 23 cases in which tibia floor plasty was not performed, 14 cases in which X-ray films were obtained during follow-up were investigated. Bone changes were visible on X-ray images in 13 cases (93 %), including 10 cases in which the tibial articular facet tunnel or the femoral articular facet tunnel was enlarged and 3 cases in which the axis of the bone tunnel was not parallel to the axis of the K-screw, indicating possible screw diversion³⁾.

Discussion

I. Problems with the BTB anchor

Although the BTB method is considered the standard method for ACL reconstruction, it is also thought to have several problems.

1. Discrepancy between the BTB length and the length from the outer femoral tunnel to the outer tibial tunnel.

In the BTB method, the patella tendon is extracted with bone pegs attached to its top and bottom. It is best if the length of this tendon segment between the bone pegs is the same as the separation distance opened between the femur and tibia during ligament reconstruction. However, in actual practice the distances do not match and the transition portion of the bone pegs and the tendon (the “bone tendon border”) is often within the tunnel. Furthermore, the total length of the extracted BTB is not matched to the total of the length of the tunnel excavated for establishing the reconstructed ligament plus that of the reconstructed ACL between the femur and tibia. This length discrepancy leads to bone pegs being deep inside the tunnel or hinders fixation of a K-screw that protrudes from the tunnel.

2. Length mismatch between the actual bone tissue width or tunnel length and the BTB bone peg when the K-screw is inserted.

When a bone peg of the BTB is fixed within the tunnel at a position as shown in Fig. 1, the ligament is presumed to move with the point at the outlet of the tibial articular facet (point A), as the support point when the knee is flexed. However, the actual motion of the ligament is at the bone tendon border section of point B, the transition portion of the ligament and the bone of the reconstructed ligament. Because this section moves as the knee is flexed, the support point for the tibial articular facet tunnel allowing the ligament to move is remodeled from point A to point A' or A". For this reason, reconstruction is considered to have failed even though knee stability was initially satisfactory (Fig. 1).

3. The tapered section of the K-screw is barely in contact during the initial setting period.

The tip of the K-screw has a tapered section about 5 mm long to facilitate insertion. This section has little significance in the initial fixing of the bone peg once the screw has been inserted inside the tunnel. If the overall separation of the BTB is great and the bone peg

Fig. 1. BTB and K-Screw in the Tibia Tunnel

Fig. 2. Screw diversion and conversion

protrudes from the tibial section, a long screw could injure the tendon segment. For this reason, a screw as long as the BTB bone peg inside the tunnel is selected.

4. Problems of screw diversion and screw conversion

Because the guide wire is not always inserted parallel to the bone tunnel, there is a danger that the K-screw will be inserted incorrectly, i.e., not parallel to the axis of the bone tunnel but either angled toward the tunnel wall (diversion) or angled toward the BTB bone peg (conversion)³⁻⁶⁾ (Fig. 2).

After the K-screw is inserted, the guide wire should be extracted easily. Resistance might indicate screw diversion or screw conversion.

5. Isometricity failure

Isometricity failure has been reported by many researchers. After the tunnel in the tibia

is opened, the length pattern^{6,9)} is calculated when the placement of the femoral tunnel is determined. Even if the femoral tunnel is created at the optimal position, since the measurements for the position are made from the center of the circular opening while the actual reconstructed ligament is pressed against the tunnel wall by the K-screw and forced to the lip of the tunnel, isometricity failures occur. If the tunnel on the tibial articular facet has been remodeled (Fig. 1), the tunnel's position will differ from that calculated during surgery and isometricity failure will occur even in the absence of instability.

II. Avoiding failures in isometricity with the BTB method

Many cases of ACL injury occur in individuals with a narrow femoral intercondyle, in other words, a narrow notch section. Notch plasty is performed to increase the notch width during ACL reconstruction, but there has been little consideration of the tibial side¹⁰⁾.

We have been subjecting the knee to maximal flexion during isometricity measurement. For cases in which a strong tension pattern for the length pattern is shown upon maximal flexion, we have compensated by excavating a groove in the bone running from the back of the tibial tunnel toward the front of the posterior cruciate ligament with a slight posterior angle, just as if the direction were toward A' rather than A in Fig. 1. We call this procedure tibia floor plasty²⁾. The length pattern is commonly calculated during surgery from an extension of 0 degree to a flexion of approximately 120 degrees. However, even if the isometricity is satisfactory up to 120 degrees, because more flexion is required for the formal, traditional Japanese sitting posture, an angle greater than 120 degrees must be calculated when the length pattern is measured.

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