10 - ORIGINAL ARTICLE
CLINICAL INVESTIGATION

Comparison of two methods of femoral tunnel preparation in single-bundle anterior cruciate ligament reconstruction. A prospective randomized study[1]

Comparação entre dois métodos de preparação de túnel femoral na reconstrução do ligamento cruzado anterior em feixe único. Estudo prospectivo randomizado

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ABSTRACT

PURPOSE: To prospectively compare therapeutic effect of femoral tunnel preparation through the tibial tunnel and the anteromedial (AM) portal in single-bundle anterior cruciate ligament (ACL) reconstruction.

METHODS: Between June 2008 and October 2010, 76 patients underwent single-bundle ACL reconstruction by autogenous grafting of semitendinosus and gracilis tendon. All cases were randomly divided into two groups according to the method of femoral tunnel preparation: transtibial (TT) group (n=38) and anteromedial (AM) group (n=38). Lysholm knee score and the KT-1000 anterior laxity at 30° of pre-and post-operation were assessed for two groups.

RESULTS: Sixty-five patients (TT group, 34; AM group, 31) were followed up for more than 12 months, with a follow-up rate of 86%. The Lysholm knee score and the KT-1000 anterior laxity 12 months after operation were significantly better than before reconstruction. The Lysholm knee score and the KT-1000 anterior laxity were not significantly different between the TT and AM groups after operation.

CONCLUSION*:* Femoral tunnel preparation through tibial tunnel or the anteromedial portal in single-bundle anterior cruciate ligament reconstruction shows same therapeutic effects.

Key words: Anterior Cruciate Ligament. Anterior Cruciate Ligament Reconstruction.

RESUMO

OBJETIVO: Comparar prospectivamente o efeito terapêutico da preparação do túnel femoral através do túnel tibial (TT) ou da porta ântero-medial(AM) na reconstrução do ligamento cruzado anterior(LCA) em feixe único.

MÉTODOS: Entre junho de 2008 e outubro de 2010, 76 pacientes foram submetidos à reconstrução do LCA em feixe único pelo enxerto autógeno de tendão semitendíneo egrácil.Todos os casos foram divididos aleatoriamente em dois grupos de acordo como método de preparação do túnel femoral: grupo transtibial (TT) (n=38) e grupo ântero-medial (AM) (n=38). Foi usado o escore Lysholm para joelho. O relaxamento anterior do joelho a 30° sob força tênsil de 133,32N foi determinado com o medidor KT-1000 no pré e no pós-operatório nos dois grupos.

RESULTADOS: Sessenta e cinco pacientes (grupo TT, 34; grupo AM,31)foram acompanhados por mais de 12 meses, com uma taxa de follow-up de 86%.A pontuação do Lysholm para joelho e do relaxamento anterior medido pelo KT-1000 aos 12 meses de pós-operatório foi significativamente melhor do que antes da reconstrução.As pontuações de Lysholme do relaxamento KT-1000 não foram significativamente diferentes comparando os grupos TT e AM após a operação.

CONCLUSÃO: A preparação do túnel femoral através do túnel tibial ou da porta ântero-medial na reconstrução do ligamento cruzado anterior em feixe único mostrou os mesmos efeitos terapêuticos.

Descritores: Ligamento Cruzado Anterior. Reconstrução do Ligamento Cruzado Anterior.

Introduction

Anterior cruciate ligament (ACL) is an important structure to stabilize the knee joint and its injury can induce knee joint laxity and even traumatic arthritis. Early reconstruction is of great significance for recovery of functions of the knee joint. ACL reconstruction is a hot spot in the articular surgery which focuses on graft types, fixing method, surgical procedures and tendon-bone healing as well as postoperative rehabilitation. There are currently various ACL reconstruction procedures but no criteria are acknowledged. Femoral tunnels can be prepared with transtibial (TT), anteromedial (AM) and outside-in techniques[1]. As for the clinical efficacy of femoral tunnels with different surgical procedures, morphological outcomes are given much attention to but functional recovery is rarely investigated[2-5]. In this study, single-bundle ACL reconstruction was conducted by grafting autogenous semitendinosus and gracilis tendon and effects of the two procedures on postoperative functional recovery were prospectively compared.

Methods

A total of 76 consecutive patients (56 males and 20 females) with an average age of 28 years (range 17 to 48 years) underwent single-bundle ACL reconstruction by grafting autogenous semitendinosus and gracilis tendon from June 2008 to October 2010. All patients were randomized into TT (n=38) and AM (n=38) groups to receive either of the two procedures. The two groups were matched in age, sex, injury causes and meniscus injury. Injury causes included sport injuries (n=24), military training injuries (n=31) and traffic accident injuries (n=21). The documented sport was basketball for 15 patients, football for five patients, wrestling for two patients, and snow skiing for two patients. The documented military training was 400m obstacle running for 20 patients, fighting basic skills training for six patients, kick sandbags training for three patients, and forced march at night two patients. The documented traffic accident was collision for 16 patients, and fall off the cycle for five patients. Major manifestations were knee joint laxity, pain and swelling, aggravating in running and climbing upstairs and downstairs. Physical examinations showed atrophy of quadriceps femoris and positive anterior drawer test (ADT) and Lachman test. ACL broke completely in all patients, and was confirmed by arthroscopy, and meniscus injury was also present in 19 patients.

Construction of tibial tunnel

ACL tibial positioner was positioned postoperomedially of the center point of the remnant attachment part in the tibia-in the extension line of free edge of the anterior horn of lateral meniscus and 2mm medially of tibial internal spine within the joint and 2m medially of tibial tubercle outside on the surface of the joint. The positioner was calibrated in a 45° angle, followed by advancing the guide pin. Tibial drills were selected according to the diameter of grafting tendons and the hole was drilled along the guide pin to construct tibial tunnels.

Construction of femoral tunnel

Femoral tunnels were constructed via tibial tunnels in 38 patients and AM portals in 38 patients.

In the TT group, the knee joint was flexed at 90°. Then, a proper positioner for femoral tunnel was placed via the tibial tunnel and guide pins were knocked at 10 to 11 o'clock direction of the right knee and 1 to 2 o'clock direction of the right knee, respectively. A drill with the diameter consistent with the grafting tendon was selected with the drilling depth of 3cm. The guide bar with the diameter consistent with the tunnel was inserted into the femoral tunnel via the tibial tunnel after connecting with the aiming device. Two interlocking holes were created on the top of the femoral end. Rigidfix pins were made to fix the approach.

In the AM group: The knee joint was flexed at 120°. The positioner for femoral tunnel was placed via the AM port to drill the femoral tunnel. Then, the guide bar with the diameter consistent with that of the tunnel was inserted into the femoral tunnel via the AM incision after connecting with the aiming device. Two interlocking holes were drilled on the femoral end. Rigidfix pins were created to fix the approach.

Placement and fixation of grafting tendon

Grafting tendons were introduced into the bottom of the femoral tunnel via the femoral tunnel, penetrating the attachment part of remnant ligament in the tibia. The femoral and tibial ends were fixed with Rigidfix and Intrafix systems, respectively. Tension and stability of reconstructed ligament were tested. Collision was observed in knee extension and in the presence of collision, intercondylar's plasty was conducted.

Postoperative rehabilitation

The both groups conducted the same postoperative rehabilitation regimens. Isometric contraction exercises of ankle pump and quadriceps femoris were practiced immediately post surgery. On the second day post surgery, leg raising straight and side leg lifting exercises were practiced and before exercise, the foot pad should be forced to flex, followed by slowly lifting and putting back, with standing at 45°C for five seconds. The knee joint could flex to 90° in postoperative four weeks and to the contralateral level in postoperative six weeks. Besides practicing the joint flexion function, the knee joint was fixed in the straight position with the brace in the first six weeks following surgery. Patients could stand with the leg straight under the protection of braces four weeks later postoperatively, completely bore weighting in the aid of braces and practiced squatting and single-leg knee-flexion three months postoperatively. 6 months postoperatively, the brace was removed and patients could walk normally and take flexibility training, including walking forwards, backwards and laterally.

Statistical analysis

Functions of knee joint was scored with the Lysholm method preoperatively and 12 months postoperatively. The anterior laxity of the knee joint at 30° under 133.32N tensile force was measured with the KT-1000 knee joint meter. SPSS10.0 was used for statistical analysis. Measurement data were expressed as the mean±standard deviation (SD) and analyzed with the *t* test. $p<0.05$ was considered statistically different.

Results

Of 76 patients, 65 (86%) were followed up for at least 12 months. Before surgery, Lysholm scores were 69.7±4.8 and 66.7±5.2 before surgery and 94.5±1.1 and 95.1±1.0 in postoperative 12 months in the TT and AM groups, respectively. KT-1000 anterior laxity at 30° of knee flexion was 4.35±1.65mm and 4.08±1.94mm before surgery and 2.14±0.91mm and 1.96±1.02mm in postoperative 12 months in the TT and AM groups, respectively. Lysholm scores and KT-10000 anterior laxity were significantly improved after treatment with surgery but did not differ statistically between two groups (Tables 1 and 2).

TABLE 1 - Lysholm scores before and after ACL reconstruction in both groups.

	Preoperatively	Postoperatively
TT group	69.7±4.8	94.5±1.1*
AM group	66.7±5.2	95.1±1.0*

*No significant difference was noted between groups after surgery: t=0.412, p=0.716

TABLE 2 - KT-1000 anterior laxity of knee joint at 30°C flexion after ACL reconstruction in both groups (mm).

	Preoperatively	Postoperatively
TT group	4.35±1.65	2.14±0.91**
AM group	4.08±1.94	1.96±1.02**

**No significant difference was noted between groups after surgery: t=1.021, p=0.351

Discussion

Femoral tunnel is very important in ACL reconstruction. Ideal tunnel should enable the tension of the graft to minimize during the whole activity of the knee joint. Xu *et al*.[6] made a study on knee joints of seven cadaver specimens and found that the middle point of ligament-attached region could be used for ligament reconstruction but was not the ideal position and the posterior point of the attachment region of ACL in the femur was the ideal isometric reconstruction point. It has been demonstrated that slight changes of femur-ending point can significantly affect the length and tension properties of ligament, for example, anterior and inferior femoral locations can cause the reconstructed ligament to relax in straightening and tighten in flexing while superior location induces the opposite effects. Due to ACL chronic injury, the femoral end is often absorbed and disappears during surgery and consequently, the surgery takes the posterior edge of the outer wall of the intercondylar fossa but not the fiber of remnant end of femur as the positioning marker. Through cadaveric biomechanical studies, Loh[7] proved that the 10 o'clock position was superior to the 11 o'clock position in limiting the rotation and more approached the biomechanical properties of natural ACL. Pinczewski[8] also deemed that locations of tibial and femoral tunnels had direct effects on inclination angle of graft (line feed) and the vertical angle was positively associated with anterior displacement of tibia relative to femur, which will directly affect the long-term efficacy of ACL reconstruction.

Currently, there are outside-in, TT and AM techniques for location of femoral tunnel and which is the most proper is still disputed. The outside-in technique needs the AM approach for tibial operations and another lateral incision in the femoral metaphysic to create the femoral tunnel with the outside-in method. The other two methods use the in-outside method to construct the femoral tunnel, which has no bottom blind end, not beneficial for location and fixation of Rigidfix pin. TT and AM techniques have respective advantages and disadvantages.

As for the TT technique, which is the most generally used, the deviation of the frontal angle between tibial and femoral tunnels is minimal; additionally, for the femoral tunnel is constructed in knee joint flexing at 90°, the saggital axis of femoral tunnel is more close to the axis of grafting tendon, which can prevent the contact stress of the anterior wall of the tunnel[9]. Besides, it is less time-consuming because the operator can pay all attention in construction of tibial tunnel and complete the location of two kinds of tunnels once. However, it is hard for the ending point of the femoral tunnel via the tibial tunnel to completely coincide with the anatomic ending point and the complete coincidence can be completed only in accurate position and angle of the tibial tunnel. In this study, the inner opening was positioned posteriomedially of the center of the remnant attachment part in the tibia-in the extension line of the free edge of the anterior horn of lateral meniscus and 2mm anteriorly of the tibial tubercle within the joint and 2cm medially of tibial tubercle on the surface of the joint, which is convenient for construction of femoral tunnel. During surgery, the angel between the tibial tunnel and the joint line was set as 40° or 45° to easily drill the femoral tunnel without the inner opening higher or anterior of the normal anatomic point.

Considering disadvantages of the TT technique such as the anterior and high position of femoral tunnel, the AM technique is preferred by some operators. The AM technique is not restrained by the tibial tunnel, the tunnel more approaches the anatomic position and posterior wall is not easy to blowout due to the right angle between the tunnel and Blumensatt line. Xu *et al*.[10] investigated the effect of two techniques on bone tunnel enlargement in single-bundle ACL reconstruction and found that drilling the femoral tunnel with AM technique could created a lower, more posterior, and less vertical tunnel and result in smaller postoperative tunnel enlargements. But they didn't show a significant correlation between tunnel enlargement and clinical outcomes. However, this technique requires joint flexion of more than 120°, causing the poor visual field and narrow operational space to easily induce cartilage injuries in drilling the tunnel. Additionally, the tunnel axis is inconsistent with the grafting tendon axis at the sagittal plane and the included angle increases in the straight position, easily leading to a high pressure of grafting tendon to the anterior wall of the tunnel and enlargement of the tunnel. These problems should be resolved by further studies.

TT and AM techniques are compared for respective advantages and disadvantages in some studies with different methods. Bowers *et al*.[2] compared ACL tunnel position and graft obliquity with transtibial and anteromedial portal femoral tunnel reaming techniques using three-dimensional high-resolution magnetic resonance imaging and found that although both technique can capture the native femoral footprint, the TT technique requires significantly greater posterior placement of tibial tunnel, resulting in position of tibial tunnel by the AM technique more close to the native ACL anatomic position. Miller *et al*.[3] simulated ACL reconstruction in cadavers and compared the two methods in constructing the femoral tunnel using the CT examination. Results showed that with the AM technique, the length and volume of the femoral tunnel were shorter and smaller, the aperture shape was more of an ellipse and the posterior wall was thinner. Segawa *et al*.[4] found that as compared to the AM technique, the TT technique was associated with a larger sagittal angle between the femoral tunnel and longitudinal axis of femoral shaft, which increases the contact pressure of the anterior wall of the funnel, resulting in enlargement of the inner opening of the tunnel and more possibility of grafting ligament laxity. Bedi *et al*.[5] examined 18 cadaveric knees with CT and indicated that the AM portal technique allowed for greater femoral tunnel obliquity compared with the TT technique and could place the graft more close to the anatomic position of femoral condyle, which produces better efficacy of recovering the rotation stability. He also stressed, however, there was a substantially increased risk of critically short tunnels and posterior tunnel wall blowout. By following up patients with ACL reconstruction using the TT or AM technique for drilling the femoral funnel for two to five years, Alentorn-Geli *et al*.[11] found that the AMP significantly improved the anterior-posterior and rotational knee stability, IKDC scores and recovery time compared to the TT technique. Gurpur Kini commented results of Alentorn-Geli and concluded that the poor efficacy in the TT group was attributed to the too perpendicular procedure in preparing the tibial tunnel with the included angle with the coronal plane of only 20°and the efficacy could be improved if the coronary included angle with the tibial tunnel was increased to 60 to 70[12]. Sim *et al*.[13] demonstrated a comparable efficacy of both methods in preparing the femoral tunnel from the biomechanical view. This study investigates effects of different methods for preparing the femoral tunnel on the knee joint function following surgery from the functional angle and results suggest that the both methods can result in an excellent functional recovery of knee joint only if the procedures are correct and proper.

Conclusion

Femoral tunnel preparation through tibial tunel or the anteromedial portal in single-bundle anterior cruciate ligament reconstruction shows same therapeutic effects.

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