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Original article

The role of computer assisted navigation in revision surgery for failed anterior cruciate ligament reconstruction of the knee: A continuous series of 52 cases

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ABSTRACT

Introduction: The causes of failure of anterior cruciate ligament (ACL) reconstruction mainly involve incorrect tunnel positioning. There is no intraoperative tool allowing the surgeon to test graft biomechanics and to confirm that the new graft is in an optimal position.
Hypothesis: Control is improved with computer assisted navigation.
Material and methods: In this retrospective study, revision ACL reconstruction was performed with a new autologous graft in a continuous series of 52 failed ACL reconstructions. A computer assisted navigation system was used intraoperatively in all knees. Evaluation with this system confirmed the position of old and new tunnels as well as intraoperative laxity.
Results: Evaluation of tunnel position based on traditional radiological criteria found in the literature significantly underestimated graft biomechanics: 69% of the cases presented with unfavorable graft ansiometry (mean: 13 ± 2.2 mm) while the correct position of the tibial tunnel was identified in 64% of cases on radiography and the femoral tunnel in 48%. All new grafts were optimally positioned by the computer assisted navigation system with a mean isometery of 3.2 (±0.7) mm. Comparative pre- and postoperative evaluation of laxity showed a statistically significant improvement ($P < 0.001$): preoperative and postoperative Lachman test: 10.5 ± 2 mm and 3 ± 0.5, respectively; global rotational laxity: 24 ± 5° and 37 ± 7° respectively.
Conclusion: The use of a computer assisted navigation system allows optimal positioning of the graft as well as a predictive assessment of laxity.
Type of study: Level IV, retrospective cohort study.

1. Introduction

Surgical reconstruction of the anterior cruciate ligament (ACL) has become routine: there are approximately 35,000 ligament reconstructions per year in France. A failure rate of between 11 and 20% has been reported in the literature [1–3] with persistent knee instability and rotational laxity with the presence of a positive "pivot shift test" [4,5]. An analysis of the causes of these failures is essential before performing any surgical procedure. Although it is difficult to evaluate, one of the most frequent causes is incorrect tunnel positioning [6–9]. Indeed, analysis of graft position is based on radiographic or MDCT criteria whose reproducibility and interpretation are a subject of debate [10]. However, correct anatomic and isometric tunnel positioning is essential. How can correct tunnel positioning be confirmed during revision surgery? The position should be anatomical within the native area of the ACL, as isometric as possible and should not impinge the intercondylar notch. [11]. According to Gillquist [12], there are significant interindividual anatomical variations in correct tunnel position. For Jagodinzky [13], optimal tibial tunnel positioning to avoid intercondylar notch roof impingement ranges from using 36% to 62% of the width of anteroposterior tibial insertion surface. There is no predefined position to ensure optimal tunnel placement for the surgeon with conventional tools; especially since the definition of correct tunnel position also varies in relation to each surgeon's preference [14]. The quality of tunnel positioning is largely responsible for the

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differences in objective clinical results observed in the literature with good and very good results ranging from 75 to 90% [15].

Thus, to improve these results, the accuracy of tunnel positioning needed to be improved: surgical computer assisted navigation systems made it possible to achieve this goal. Since 1993 numerous studies in Grenoble, France, have allowed us to develop and apply the concept of an anatomometric positioning of the ACL based on the use of a computer assisted navigation system to obtain a minimal favorable anisometric profile for the graft that does not impinge upon the femoral intercondylar notch [16,17]. At present the computer is the only tool capable of measuring these parameters. We therefore systematically used the computer assisted navigation system for revision ACL surgery to look for a relationship between failed ACL reconstruction and possible graft malposition.

The goal of this study was to analyze the intraoperative intraarticular anatomical and biomechanical results in a continuous series of 52 primary ACL reconstruction failures and to describe a procedure of revision ACL reconstruction using a computer assisted navigation system. This system made it possible to analyze knee kinetics, laxity before and after revision surgery and to record the position of old and new tunnels as well as the isometrics of old and new grafts.

2. Materials and methods

This is a retrospective study in a continuous series of 52 patients (mean age: 27 years old (20–45), 18 women – 34 men, 34 left knees – 18 right). After failure of primary ACL reconstruction (1 synthetic ligament, 30 semitendinosus gracilis [STG] grafts, 21 bone-patellar tendon-bone [BPTB] grafts) all patients underwent revision ACL reconstruction. Patients under the age of 18 when the first graft was performed were excluded. The mean interval between the first ACL reconstruction and the second was 26 months (6–84 months). A sports injury was the cause of the tear in 60% of the cases.

The clinical exam identified a (+) Lachman test in 12 cases and (++) in 40 cases, the presence of slight rotational laxity in 28 cases and (+) in 24 cases. The mean preoperative laxity on radiological Telos® (150N) was 10 ± 3 mm (7–15).

The surgical technique involved using STG tendon grafts (simple or double bundle) in case of BPTB or synthetic ligament failure and a BPTB graft in case of STG failure. In case of significant preoperative laxity in particular rotational laxity, double bundle ligament reconstruction (7 cases) or lateral tenodesis (3 cases) were performed (Table 1).

3. Computer assisted navigation technique

The computer assisted navigation system described by Julliard [16] and Plaweski et al. [17] was used with the Surgetics workstation (Praxim Medivision®, La Tronche, France) and software for ACL reconstruction (ACL Logics® Praxim Medivision®, La Tronche, France) without pre- or intraoperative imaging; only anatomical references were used. Virtual images were adapted to conform to the anatomical reality of the patient's intercondylar notch [18] using the Bone Morphing® procedure. The centers of the primary reconstruction tunnels were visualized. They were recorded by the operator on the anisometry map drawn by the computer. Thus, virtual anisometry of the primary graft could be controlled. The choice of new tunnels was based on this assessment: either the positioning of the primary tunnels was good and could be preserved or it was incorrect and they were abandoned and new tunnels were drilled following the tunnel position presented on the computer screen which presented minimal anisometry and no impingement with the intercondylar notch.

Each knee was evaluated for laxity by an intraoperative Lachman test before and after graft placement (measurements obtained by the computer assisted navigation system). Each measurement was repeated three times and the highest value was recorded. Rotational laxity was evaluated using the same protocol with the knee in 20° flexion with the highest value recorded for each test.

The recorded values were presented as means and standard deviations. Results were analyzed using the student *t*-test and $P < 0.05$ was considered to be significant.

Table 1
Surgical techniques: primary surgery and revision surgery.

	Primary	Revision
BPTB	21	30
STG	30	15
Synthetic ligament	1	
Double bundle		7
Associated lateral tendonesis		3

BPTB: bone-patellar tendon-bone reconstruction; STG: semitendinosus gracilis graft.

4. Results

4.1. Laxity assessment

Mean preoperative and postoperative anterior laxities were 10.5 ± 2 mm (8–17 mm) and 3 ± 0.7 mm (1–7), respectively (Table 2). The preoperative and postoperative global rotational laxities (difference between maximum internal and external rotational laxities) were 37 ± 7 degrees (28–52) and 24 ± 5 degrees (18–30), respectively.

The influence of laxity on the surgical procedure: associated anterolateral reconstruction was performed in 3 cases with insufficient correction of rotational laxity (estimated values after ACL reconstruction were less than 20% of the correction of values determined before graft placement by the computer assisted navigation system).

4.2. Analysis of tunnel position

The position of the tunnels was assessed on AP and lateral X-rays of the knee in full extension based on criteria defined by Howell et al. [20] and Aglietti [21]. Geometric values for this analysis are set out in Fig. 1 with criteria for tibial tunnel positioning (ATB) and criteria for femoral tunnel positioning (AB/AC) (Fig. 1).

The preoperative position of the femoral tunnel tended to be anterior (mean preoperative AB/AC = 58.4 ± 8.3) with an index < 60% in 52% of the cases and was correct in all postoperative cases (index > 60%: mean AB/AC = 65.9 ± 4.5). The preoperative position of the tibial tunnel was incorrect in 36% of the cases (impingement of the intercondylar notch) (negative preoperative ATB: mean = –0.31 ± 2.69) and was correct postoperatively in all cases without impingement with the intercondylar notch (ATB postoperative: mean = 1.2 ± 0.76) (Figs. 2 and 3).

4.3. Biomechanical analysis

The preoperative anisometry curve was unfavorable in 36 cases (69%), and favorable or neutral in 16 cases (Table 2). In the 36 unfavorable cases, mean anisometry was 13 ± 2.2 mm (7–19). The mean anisometry after revision was favorable in all cases and was 3.2 ± 0.7 mm (1–5) (Figs. 4 and 5). In the 7 cases of double bundle reconstruction, the anteromedial bundle was isometric in all cases and the mean isometry of the posterolateral bundle was favorable (3.5 ± 0.5 mm) (2–7).