EFFECT OF GRAFT POSITION ON LAXITY AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Stress radiography in 90 knees 2 to 5 years after autograft

B. BODEN[1], H. MIGAUD[1], F. GOUGEON[1], M. J. DEBROUCKER[2], A. DUQUENNOY[1]

The effect of tibial and femoral graft placement on radiographic laxity after anterior cruciate ligament reconstruction was studied in 90 knees. All the knees were operated according to the Marshall-MacIntosh procedure with a through-the-condyle technique. Graft position and laxity were determined on lateral xrays (static and mechanically assisted 200 Newtons anterior drawer strain).

No relation was observed between tibial tunnel position and radiographic laxity. In fact few variations in placement were recorded. Femoral tunnel placement was more dispersed, and it strongly influenced the radiographic laxity ($p = 0.0001$). Laxity was minimal when the center of the femoral tunnel was 6 mm below the intercondylar notch roof and 2.5 mm behind the posterior margin of the notch. No correlations were observed between tunnel positions and function evaluated with the ARPEGE score.

These results stressed the importance of the femoral graft placement to control laxity after anterior cruciate ligament reconstruction, and allowed determination in vivo of a position for which minimal laxity could be expected. Since the method determining the femoral graft placement in the present study was not precise, we now use fluoroscopic control to determine drill-guide position.

Keywords : knee ; instability ; knee injuries ; anterior cruciate ligament.

Mots-clés : genou ; instabilité ; laxité ; ligament croisé antérieur ; ligamentoplastie.

INTRODUCTION

The results of anterior cruciate ligament (ACL) reconstruction are influenced by the nature of the ligament : prosthetic ligaments (15, 16) give less good results than auto or allografts (8, 21) and the reconstruction technique using arthroscopic assistance permits faster rehabilitation than conventional surgery (3, 22). The influence of the graft position on ligament tension and knee motion has been demonstrated by several in vitro studies (1, 11, 25, 28, 30). However, these studies determined many different isometric sites that are not easy to identify during surgery, and the efficiency of which on laxity control is not always reported in vivo. Indeed, few studies evaluate in vivo the influence of graft position on laxity measurements (10, 14, 18). Our aim was to devise a method of identification of femoral and tibial graft position and to determine the influence of graft position on laxity and function after ACL reconstruction.

PATIENTS AND METHODS

We analyzed 101 ACL reconstructions (91 patients) performed by one surgeon (F. G.) between January 1989 and December 1992 and followed prospectively. Eleven patients were excluded because of inappropriate xrays. Ninety plasties were consequently included, performed in 80 patients whose mean age was 24.5 ± 6 years (15-44). All the patients had symptomatic anterior chronic laxity (giving-way accidents during occupational or sports activities). All knees had positive Lachman and pivot-shift tests. According to Moyen *et al.* (19),

[1] Department of Orthopedics B, University Hospital, 59037 Lille CEDEX, France.

[2] Clinique des Peupliers, 109 rue d'Hem, 59650 Villeneuve d'Ascq, France.

Correspondence and reprints : H. Migaud.

the Lachman test was rated from 1 + to 3 + : 8 knees were rated 1 + 74 rated 2 + and 8 rated 3 +. Twenty-one knees had a past history of meniscectomy before they were included in the study (14 medial, 3 lateral, 4 medial and lateral). The mean interval between the ACL tear and reconstruction was 945 ± 109 days (30-4179 days). Preoperative functional status (table I) was evaluated according to the ARPEGE scoring system (7). This score evaluates function according to three criteria (pain, stability, mobility) rated from 0 (minimum) to 9 points (maximum). The functional score, sum of the three parameter rates, was balanced according to four patient levels of activity (competitor, leisure sports, active, sedentary).

Operative technique

All reconstructions were carried out by a senior surgeon (F. G.) who performed 50 procedures before the 101 included in the present study. Following Marshall *et al.* (17), the graft was taken from the medial third of the patellar ligament and the central strip of the quadriceps tendon connected with prepatellar tissue. Notchplasty was performed in all cases at the expense of the lateral condyle and the intercondylar roof. The tibial tunnel was drilled free-hand, after a medial para-patellar arthrotomy, so that its superior opening would be in the remnant of the ACL. A 10-mm femoral tunnel was drilled through a lateral approach and the aiming (posterosuperior aspect of the medial wall of the lateral condyle) was controlled by the tip of a finger introduced into the posterior part of the notch. The graft remained attached to the tibial tubercle. It was long enough to be secured to the iliotibial band with absorbable sutures. The graft was stretched manually and sutured with the knee in 30° of flexion. Under arthroscopic control, 34 medial meniscectomies were performed during the reconstruction procedure (31 partial, 3 total), and 24 lateral meniscectomies (23 partial, 1 total). The rehabilitation program began on the second postoperative day, full weight-bearing was allowed after 5 weeks and sports activities after 6 months.

Clinical assessment

The 90 plasties were prospectively followed by the physiotherapist (M. J. D.) who managed the rehabilitation program after all the procedures. Evaluation was made by means of functional assessment according to the ARPEGE scoring system (7), and by observation for the Lachman and pivot-shift test.

Radiographic assessment

Radiographic analysis was performed by an observer (B. B.) unaware of the functional result. Evaluation was made from the xrays obtained at follow-up : a lateral nonweight-bearing view and a dynamic lateral view with 200 Newtons anterior tibial stress applied with Telos™ instrumentation (31). Identification of the tunnels was made using the sclerotic bone margin around the articular opening of the tunnels. Femoral tunnel position was determined with respect to two perpendicular axes (OXF, OYF) drawn on lateral xrays (fig. 1). The OXF axis was Blumensaat's line, and the OYF axis was perpendicular to OXF and tangent to the posterior aspect of the lateral femoral condyle. The position was defined according to coordinates of the center of the medial opening of the femoral tunnel (Mc). Tibial tunnel position was determined with respect to the OXT axis which was tangent to the medial tibial plateau. The point OT was located at the posterior margin of the medial tibial plateau. The position was defined according to the location of the posterior margin of the superior opening of the tibial tunnel. Anterior radiographic laxity was measured according to Stäubli *et al.* (31). In accordance with Sidles *et al.* (28), all the measurements were scaled to the length of the intercondylar notch measured on the lateral radiograph.

Statistical measurements

Qualitative data were compared by means of the Chi-square test, and quantitative data by means of linear and multiple regression analysis and by the Manova

Table I. — Functional status for 90 knees, according to the ARPEGE scoring system

	Preoperative			At follow-up		
	Mean	Deviation	Range	Mean	Deviation	Range
Pain	6.88	1.8	[0 - 9]	8.33	0.9	[4 - 9]
Stability	5.27	1.9	[0 - 9]	8.2	0.9	[6 - 9]
Mobility	8.9	0.3	[7 - 9]	9	0.2	[7 - 9]
Total	21.1	3.4	[9 - 25]	25.5	1.6	[20 - 27]

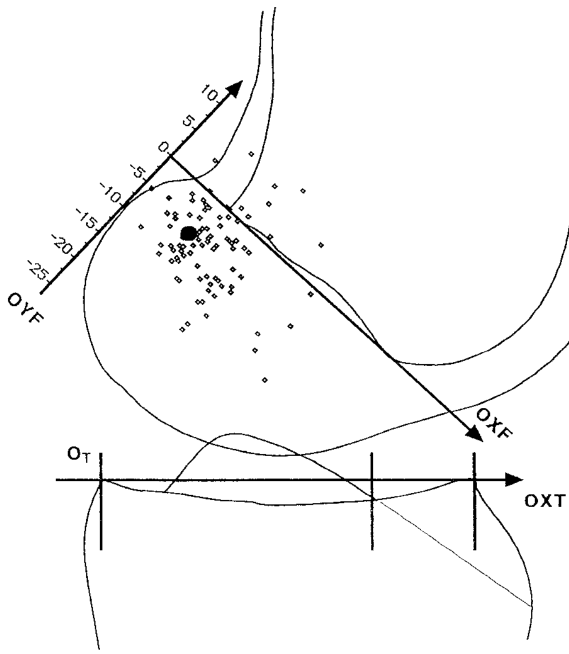

Fig. 1. — Axis of coordinates 1) for the femur. OXF is tangent to Blumensaat's line, OYF perpendicular to OXF and tangent to the posterior aspect of the lateral femoral condyle ; 2) for the bitia. OXT is tangent to the medial tibial plateau ; OT was located at the posterior margin of the medial tibial plateau. The small squares represent the centers of the medial openings of the femoral tunnels (Mc) observed for the 90 knees. The black spot represents the Mc position that was found to be associated with minimal anterior laxity. The scale for OXF, OYF, and OXT is expressed in millimeters.

test. The non-parametric Mann-Whitney test was used when the samples were small, and $p < 0.05$ was considered to be significant.

RESULTS

Clinical results after a mean follow-up of 3 years (2-5 years) are detailed in table I. Four patients had giving-way accidents, which corresponded to 4 positive pivot-shift tests. Radiographic anterior laxity was not influenced either by meniscectomies or by delay between the ACL tear and reconstruction. A positive Lachman test was observed in 9 knees (10%) (8 rated 1 +, 1 rated 2 +), among which 4 knees also had a positive pivot-shift test (4.4%). Radiographic measurements are detailed in table II. We observed a low dispersion of tibial tunnel location : the posterior margin of the superior opening of the tibial tunnel was located on the average at 71 ± 0.5% of the medial plateau length. Likewise, we observed a correlation between the length of the medial plateau and the location of the posterior margin of the superior opening of the tibial tunnel ($p = 0.0001$; $R = 0.94$). On the other hand, there was no correlation between tibial tunnel location and positive pivot-shift, positive Lachman test, or radiographic laxity. The position of the femoral tunnel was more dispersed as indicated in fig. 1. The position of Mc, with respect to couples of coordinates (X,Y), was correlated with anterior radiographic laxity ($p = 0.0001$). We determined an Mc position for which anterior radiographic laxity was minimal : 1) along OYF when Mc was located 6 mm below OXF ; and 2) along OXF when Mc was placed 2.5 mm behind the posterior margin of the intercondylar notch (fig. 1). Neither Mc position nor radiographic laxity were significantly different either with or without meniscectomy. We observed no correlation between the ARPEGE scoring system and anterior radiographic laxity or the position of the femoral or tibial tunnel.

Table II. — Radiographic measurements for 90 knees

Measurement	Mean ± SD (mm)
Intercondylar notch length along OXF	31 ± 5
Center of femoral tunnel along OXF	13 ± 6
Center of femoral tunnel along OYF	- 6 ± 5
Posterior margin of tibial tunnel	39 ± 4
Anterior tibial translation	7 ± 4

DISCUSSION

Our data underscore the influence of femoral tunnel position to control anterior radiographic laxity after ACL reconstruction with the Marshall-MacIntosh procedure. Noyes *et al.* (20), Schutzer *et al.* (30), and Hoogland and Hillen (12) found that tibial tunnel position had less influence than femoral tunnel position on AP stability. Likewise, we found no influence of tibial tunnel position on AP stability, but the limited variation in tibial position in the present study could be responsible for the lack of relationship. We omitted the analysis of AP tibial xrays, as Friederich and O'Brien (9) demonstrated the minor importance of the mediolateral position for the tibial tunnel. Several femoral tunnel position sites are described : Penner *et al.* (25), O'Meara *et al.* (24), and Jonsson *et al.* (14) recommended an over-the-top position ; Clancy (6) used a femoral tunnel with a medial opening 5 mm posterior and superior to the center of ACL femoral insertion ; Huber and Matteck (13) and Saragaglia *et al.* (27) recommended locating the Mc at the center of a circle containing the dorsal part of the lateral femoral condyle ; and Cazenave and Laboureau (4) positioned the femoral tunnel about 1 cm beyond the posterior margin of the intercondylar notch. None of these positions corresponded to the ideal point described in the present study (fig. 1). Schutzer *et al.* (30), Odensten and Gillquist (23), and Rackemann *et al.* (26) recommended placing the Mc at the center of the femoral ACL insertion as described by Arnoczky (2), but its intraoperative determination is not easy when the ACL femoral stump has disappeared. By reference to the intercondylar notch, our ideal point could be easily determined intraoperatively. On the other hand, Sidles *et al.* (28) recommended connecting femoral and tibial positions in order to obtain minimal length variations of the graft during knee motion. Friederich and O'Brien (9) working on cadavers, and Schneider *et al.* (29) in a mathematical model, determined an ideal femoral position comparable with the one described in the present study. Elongation of the graft was predicted to occur by Friederich and O'Brien (9) when femoral tunnel position was beyond or behind this ideal site, and by Sidles *et al.* (28) when above or below.

Saragaglia *et al.* (27) with the Marshall-MacIntosh procedure observed 17% pivot-shift using a prosthetic augmentation, but the femoral placement was more anterior than our ideal point. With the same procedure, Jonsson *et al.* (14) observed 36% and 22.7% positive pivot-shift respectively after an over-the-top position or a through-the-condyle tunnel. Both positions were equally distant from our ideal position, and could lead to graft lengthening as suggested by Friederich and O'Brien (9) and Schneider *et al.* (29). Like Dejour *et al.* (8) and Jonsson *et al.* (14) we found no correlation between knee functional score and AP stability. This result could cast doubt on the accuracy of the ARPEGE scoring system, and now we use the I.K.D.C. scoring system (5) which takes into account the laxity measurement. We defined our ideal femoral position with respect to the posterior margin of the intercondylar notch because this landmark is easily recognized during surgery and can serve as the site for the drill guide. The dispersion of the femoral positions observed in this study performed with free-hand femoral positioning is not acceptable (fig. 1). Consequently, we changed our femoral aiming system for arthroscopic assistance coupled with an intraoperative fluoroscopic check on the guidewire position.

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SAMENVATTING

B. BODEN, H. MIGAUD, F. GOUGEON, M. J. DEBROUCKER, A. DUQUENNOY. Verband tussen positionering van de voorste kruisbandente en laxiteit na ligamentaire reconstructie.

Het verband tussen de positionering van een voorstekruisbandente en de radiografische laxiteit werd geëvalueerd in 90 knieën.

Alle knieën werden geopereerd volgens de Marshall-MacIntosh-techniek met een femorale tunnel door de laterale condyl.

Een zijdelingse röntopname toonde de positionering van de ente en de laxiteit aan (statische en mechanische meting aan 200 N).

Er werd geen verband gevonden tussen de positionering van de tibiale tunnel en de radiografische laxiteit. De variatie van positionering was hier echter bijzonder gering.

De positionering van de femorale tunnel vertoonde daarentegen een grotere variabiliteit. Dit beïnvloedde op significante wijze de radiografisch vastgestelde laxiteit (p = 0,0001).
De AP-stabiliteit was het grootst wanneer het centrum van de femorale tunnel zich 6 mm onder het dak van de intercondylaire notch en 2,5 mm achter de posterieure rand van de fossa intercondylaris bevond.
Er werd geen correlatie gevonden tussen de positionering van de ente en de kniefunctie volgens de ARPEGE-score.
De resultaten bevestigen het belang van de femorale positionering van de femorale tunnel bij de intra-articulaire reconstructie van de voorste kruisband.
Daarom gebruiken de auteurs thans een artroscopische techniek met het oog op een preciezere positionering van de femorale tunnel.

RÉSUMÉ

B. BODEN, H. MIGAUD, F. GOUGEON, M. J. DEBROUCKER, A. DUQUENNOY. Influence de la position fémorale et tibiale du transplant sur la laxité après reconstruction du LCA.

Nous avons analysé sur 90 genoux l'influence de la position fémorale et tibiale du transplant sur la laxité radiographique après reconstruction du ligament croisé antérieur. Tous les genoux avaient été opérés selon la technique de Marshall-MacIntosh avec un tunnel transcondylien. La position du transplant et la laxité ont été mesurées sur deux radiographies de profil (statique et dynamique avec une contrainte antérieure de 200 Newtons).
La laxité radiographique n'était pas influencée par la position du tunnel tibial ; les variations de placement du tunnel tibial étaient minimes. La position du tunnel fémoral était plus dispersée et influençait significativement la laxité radiographique (p = 0,0001). La laxité était minimale lorsque le centre du tunnel fémoral était placé 6 mm au-dessous du toit de l'échancrure et 2.5 mm en arrière du rebord postérieur du toit de l'échancrure. Aucune corrélation n'a été observée entre la position des tunnels et la fonction évaluée par le score ARPEGE.
Ces résultats soulignent l'importance du placement fémoral de la greffe pour contrôler la laxité après reconstruction du ligament croisé antérieur. Nous avons déterminé in vivo une position du tunnel fémoral pour laquelle le contrôle de la laxité était le meilleur. La méthode de contrôle de la position du tunnel fémoral utilisée dans cette étude étant imprécise nous avons opté pour un repérage du guide fémoral au moyen d'un amplificateur de brillance.