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Blood loss in anterior cruciate ligament (ACL) reconstruction with and without intercondylar notchplasty: does it affect the clinical outcome?

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Abstract Blood loss is associated with any surgical procedure and should be reduced wherever possible. It was our impression that notchplasty adds to the amount of postoperative bleeding after anterior cruciate ligament (ACL) reconstruction. With posterior placement of the tibial tunnel, notchplasty is optional in many cases. This study aimed to quantify blood loss with and without notchplasty after arthroscopically assisted ACL reconstruction using bone-patellar tendon-bone autografts. We performed a prospective clinical study of 58 patients, who had undergone arthroscopically assisted autogenous patellar tendon ACL reconstruction. In group I, a notchplasty was necessary according to the local anatomical criteria (intraoperative impingement test). In group II, ACL replacement could be performed without notchplasty. Single and total day drainage volume, serum and suction drain hemoglobin (Hb) and hematocrit (Hct) levels were monitored. One year after surgery, the patients were reviewed to assess the outcome according to the IKDC and Lysholm scores and the KT-1000 arthrometer. The total drainage volume was 448 ml (range 150–550 ml) in group I and 299 ml (range 50–420 ml) in group II ($p < 0.001$). The serum hematocrit (Hct) decrease was 9.7% in group I and 7.4% in group II ($p < 0.001$). At 12 months after surgery, the IKDC and Lysholm score evaluations and the KT-1000 arthrometer measurements revealed no clinical differences between the notchplasty and non-notchplasty groups. Despite a 30% increase in blood loss, notchplasty has been shown to be a useful procedure to prevent graft impingement without negative side-effects.

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Introduction

The anterior cruciate ligament (ACL) contacts the intercondylar notch when the knee is in hyperextension [1, 2]. An excessive graft size, intercondylar notch stenosis, and too anterior tibial tunnel placement may cause impingement and failure of the graft in ACL reconstructions [3, 4]. To prevent graft impingement, widening of the femoral intercondylar notch (notchplasty) has been recommended [5]. Efforts have been made to quantify this procedure intra- and postoperatively [6]. Many other factors of notchplasty have been reported: Morgan et al. [7] analyzed its effect on the patellofemoral articulation, Mann et al. [8] studied the natural history of the intercondylar notch after notchplasty, and LaPrade et al. [9] showed the deleterious effect of aggressive notchplasty on the surrounding cartilage.

So far, there are no data available concerning the amount of blood loss associated with intercondylar notchplasty in ACL reconstruction. The purpose of this study was to quantify the blood loss with and without notchplasty after arthroscopically assisted ACL reconstruction using bone-patellar tendon-bone (BPTB) autografts. IKDC and Lysholm scores were evaluated 1 year after surgery in order to assess a possible influence of notchplasty on the clinical outcome.

Patients and methods

The study included 58 consecutive arthroscopically assisted ACL reconstructions using BPTB autografts. The patients (41 men, 17 women, mean age 28.8 years) were operated on both in the subacute (< 2 weeks after trauma; $n = 8$) and chronic phase of injury (> 6 weeks after trauma; $n = 50$). In 21 patients (36%), a notchplasty was performed to avoid graft impingement (group I). The remaining 37 patients (64%) formed group II (no notchplasty). Concomitant nonosseous intraarticular knee lesions were revealed by arthroscopy in 60% of cases (group I: 12 patients, group II: 23 patients) (Table 1). Meniscus tears were treated by partial resection.

Table 1 Concomitant knee lesions (*MRI* magnetic resonance imaging)

	Group I (n = 21, with notchplasty)	Group II (n = 37, without notchplasty)
Medial meniscus tear	7 (33.3%)	14 (37.8%)
Lateral meniscus tear	3 (14.3%)	4 (10.8%)
Medial collateral ligament rupture	2 (9.5%)	5 (13.5%)
Bone bruise on MRI	8 (38.1%)	14 (37.8%)

Collateral ligament injuries were treated nonoperatively. In 38%, magnetic resonance imaging (MRI) showed bone bruises predominantly in the lateral compartment of the injured knee (20 patients, 90%).

Surgical procedure

ACL reconstruction using BPTB autografts was performed in all patients with the same single-incision endoscopic technique. The need for notchplasty and its extent were evaluated by an arthroscopic impingement test [10] and depended on the patient's individual anatomy. The presence of joint hyperelasticity (genu recurvatum), unique notch architecture, placement of osseous tunnels, and size of the ACL graft were considered [11]. Notchplasty was directed from the intercondylar apex to the floor perpendicular to the lateral wall of the intercondylar notch. Potential areas of bony impingement were removed from anterior to posterior using a motorized burr. Graft fixation was performed using 7 (femur) and 9 (tibia) mm titanium interference screws (Propel cannulated interference screws; Linvatec, Largo, Fla., USA).

Blood loss

Intraoperatively, two suction drains were placed, one intraarticularly and the other in the donor site defect. Drains were removed when there was less than 40 ml of drainage during an 8-h nursing shift. In all patients, the suction drainage could be discontinued within 48 h after surgery. To determine the postoperative blood loss, the amount of drained fluid was measured daily. Serum hematocrit (Hct) and hemoglobin (Hb) were obtained preoperatively and 24 h after drain removal. In addition, Hct and Hb values were measured from the drained blood of the suction containers every day.

Postoperative treatment and rehabilitation

All patients were enrolled in a supervised 6-week rehabilitation program. The initial 2 weeks after surgery involved immediate postoperative continuous passive motion (CPM), control of swelling by elevated leg posture, oral intake of anti-inflammatory drugs, and isometric exercises. By 2–6 weeks after surgery, increasing flexion and full weight-bearing of the operated knee were allowed, and closed chain exercises and regular physical therapy were performed. Jogging was permitted 3 months after surgery. After performing a home exercise program, patients were encouraged to return to competitive sports 9–12 months after ACL reconstruction.

Evaluation of clinical outcome

The IKDC and the Lysholm scores [12] were evaluated 12 months after surgery. Knee joint laxity was measured with a KT-1000 arthrometer (MEDmetric, San Diego, Calif., USA). The differences in knee joint laxity between the operated knee and the contralateral normal knee were documented.

Statistical methods

Statistical analysis was performed with the software package SPSS 7.5.2. For comparison of preoperative periods, single day drainage volume, total drainage volume, serum Hb levels, serum Hct levels, and Hb levels and Hct levels of the suction drain between group I and group II patients, the *t*-test for independent samples was applied. Comparison of the Lysholm score, the IKDC score, and the calculated anteroposterior (AP) translation was carried out with the Mantel-Haenszel test. Statistical significance was defined as $p \leq 0.05$.

Results

In group I (n = 21 with notchplasty), the ACL reconstruction procedure was performed 25 weeks after the initial injury (range 3–81 weeks), whereas in group II (n = 37 without notchplasty), the same procedure was performed 11 weeks after trauma (range 0.5–36 weeks). This difference was highly significant (p = 0.002).

Blood loss

Intraoperative blood loss values were not detected since sponge weights and visual blood loss were influenced by the joint irrigant dilution used for arthroscopy. Postoperative blood loss was reflected in the mean total and single day drainage volume (postoperative days 1 and 2) measured within 48 h after surgery. In group I, 448 ml (range 150–550 ml) of suction fluid was measured as mean total drainage volume, whereas in group II the mean volume was 299 ml (range 50–420 ml). Similar differences were found for the single day drainage volumes in both groups [days 1 and 2 after surgery with 337 ml (range 150–470 ml) and 111 ml (range 10–250 ml) in group I, 234 ml (range 50–470 ml) and 65 ml (range 10–360 ml) in group II, respectively). Differences were statistically significant (*t*-test for paired values, $p \leq 0.05$) for total and single day volumes (see Table 2). In order to sort the 'bloody' components of the drained fluid from the joint irrigant dilution used for the arthroscopic procedure, hematocrit (Hct) and hemoglobin (Hb) values were measured from the suction drains.

Group I patients had higher Hb (g/dl) and Hct (%) values in the suction drain for both postoperative days (8.7 g/dl; 24.8% on day 1, 6.9 g/dl; 20.6% on day 2) than group II (7.8 g/dl; 24.6% on day 1, 5.2 g/dl; 15.8% on day 2). The pronounced decrease of suction-drain Hb (5.2 g/dl) in group II on the 2nd postoperative day reflected a less intense ongoing bleeding compared with group I (Hb: 6.9 g/dl).

The mean preoperative levels of serum hemoglobin (Hb) and serum hematocrit (Hct) were equal in both groups (15.3 g/dl, 45.2% in group 1 and 15.5 g/dl, 44.4% in group 2). The Hb/Hct levels, obtained 24 h after drain removal, were 12.1 g/dl, 35.5% for group I and 13.1 g/dl, 37.0% for group II with a significant difference for Hb values ($p < 0.05$). Moreover, comparison of the Hb and Hct decrease after surgery was significant (group I: Hb (g/dl)/Hct (%) –3.2/–9.7; group II: Hb (g/dl)/Hct (%) –2.1/–7.4)

Table 2 Results of blood loss and values measured (*Hb* hemoglobin, *Hct* hematocrit)

	Group I, with notchplasty (mean values)	Range	Group II, no notchplasty (mean values)	Range	*p* values ≤ (*t*-test)
Time to surgery (weeks after injury)	25.5	3–81	10.9	0.5–36	0.002
Blood loss (ml): single volume					
day 1	337	150–470	234	50–470	< 0.001
day 2	111	10–250	65	10–360	0.014
total volume	448	150–550	299	50–420	< 0.001
Hb (g/dl) from suction drain:					
day 1	8.7	4–12.9	7.8	4.3–10.5	0.32
day 2	6.9	2.1–11.4	5.2	2.1–11.5	0.089
Hct (%) from suction drain:					
day 1	24.8	12.6–33.9	24.6	13–32	0.93
day 2	20.6	8.3–33	15.8	2.3–35	0.12
Serum Hb (g/dl):					
preoperative	15.3	12.7–17.6	15.2	11.9–17.9	0.79
postoperative	12.1	9.5–15	13.1	9.1–15.7	0.02
difference	–3.2		–2.1		< 0.001
Serum Hct (%):					
preoperative	45.2	37.1–52	44.4	36.3–51	0.43
postoperative	35.5	28–44.5	37.0	29.2–44.1	0.18
difference	–9.7		–7.4		0.006

Table 3 Lysholm score (90–100 points: very good, 89–80: good, 79–70: moderate, < 70: poor) 12 months after ACL reconstruction with and without notchplasty (not significant)

	Group I (*n* = 20 patients)	Group II (*n* = 34 patients)
Very good	45% (9)	32% (11)
Good	50% (10)	56% (19)
Moderate	5% (1)	12% (4)
Poor	–	–

Table 4 IKDC score 12 months after ACL reconstruction with and without notchplasty

	Group I (*n* = 20 patients)	Group II (*n* = 34 patients)
A = normal	35% (7)	38% (13)
B = nearly normal	55% (11)	53% (18)
C = abnormal	5% (1)	6% (2)
D = very abnormal	5% (1)	3% (1)

(Table 2). No patient required a postoperative transfusion for hemodynamic instability. Patients whose serum hematocrit fell below 30 were placed on ferrous sulfate supplements; this affected 4 patients of group I and 1 patient of group II.

Clinical outcome

Twenty patients of group I (95%) and 34 patients of group II (92%) were followed up 12 months after surgery. In 2 out of 54 examined patients (3.7%), 1 in each group, we found a persisting extension deficit of more than 10°. In these patients, the postoperative blood loss did not exceed the mean values measured for each group (Table 2). Lateral radiographs ruled out too anterior tibial tunnel placement. Any global forms of arthrofibrosis could not be detected.

Table 5 Knee laxity measurements (side-to-side difference) using the KT-1000 arthrometer

	Group I (*n* = 20 patients)	Group II (*n* = 34 patients)
< 3 mm	11 (55%)	19 (56%)
3.5–5 mm	8 (40%)	12 (35%)
≥ 6 mm	1 (5%)	3 (9%)

There was no significant difference in the clinical evaluation between the two groups with regard to their IKDC and Lysholm scores [12] (see Table 3 and 4).

Due to the different mode of evaluation, the IKDC score accords an inferior clinical outcome to the same patients in contrast to the Lysholm score, because the worst result of all 7 test subgroups primarily influences the result of the IKDC score.

The calculated AP displacement of the operated knee also showed no significant differences between these two groups (Table 5).

Discussion

Arthroscopic notchplasty is a well established method to avoid an impingement of an ACL graft [5]. Commonly, there are several causes of ACL graft impingement in the extended knee that make a notchplasty mandatory such as: a congenitally narrow notch; stenosing osteophytes in chronically unstable knees, and anterior tibial tunnel placement [13, 14]. As recommended by Johnson et al. [10], the need for notchplasty and its extent in our patients depended on the arthroscopic impingement test. A 3- to 5-mm notchplasty was performed to remove potential areas of bony impingement.

Of the 21 patients receiving a notchplasty, 16 (76%) showed stenosing osteophytes on plain X-rays, and 5 (24%) had a congenitally narrow notch at surgery. Accordingly, the preoperative period between initial trauma and surgery was significantly longer in patients receiving a notchplasty (25 ± 3.5 weeks) compared with the control group (11 ± 2 weeks, Table 2). This significant difference indicates that knee instability may predispose to early osteophyte formation and stenosis of the intercondylar notch. This supports the findings of Good et al. [15], who noted early osteophyte formation in the acute ACL-deficient knee.

Different techniques, pitfalls, and complications of the ACL reconstruction method have been studied extensively by various groups. So far, only Berg focused on blood loss associated with arthroscopic ACL reconstruction [16]. He reported an average postoperative blood loss of 372–475 ml, reflected in a mean 9-point serum hematocrit decrease after the procedure. These values are similar to those obtained in our study. However, there are no studies analyzing the effect of notchplasty on the amount of blood loss after ACL replacement.

Our results showed that notchplasty increased the total blood loss by about 150 ml (33%). Intraoperative blood loss values were not considered because estimation of visual blood loss and sponge weights was imprecise and disturbed by joint irrigant dilution. A considerable amount of the drained volume might have been joint irrigant dilution.

However, the difference of serum Hct decrease was significant [group I (notchplasty): 9.7; group II (no notchplasty): 7.4; $p = 0.006$], confirming the higher amount of blood loss following notchplasty. In order to sort the 'blood' components of the drained fluid from the dilution, Hct and Hb values were measured from the suction drains. These values not only supported the expected increase in blood loss but also revealed higher and longer-lasting peak levels, reflecting the amount of injured cancellous bone after notchplasty.

In 2 (3.7%) out of 54 patients (1 patient/group), we found a persistent loss of extension of more than 10°. This incidence was consistent with previously published data [17, 18]. The 30% increase in blood loss following notchplasty did not have any influence on the clinical outcome after a 1 year follow-up. Subjective and objective data, reflected by the Lysholm and IKDC scores and KT-1000 measurements, were similar in both groups.

In conclusion, notchplasty in BPTB ACL replacement surgery resulted in a 30% increase of postoperative blood loss. Knee laxity measurements and the functional outcome after 1 year were the same with and without notchplasty. Despite a moderate increase in blood loss, notchplasty has been shown to be a useful procedure in order to prevent graft impingement without negative side-effects, such as arthrofibrosis.

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