Mini-invasive technique for bone patellar tendon bone harvesting: its superiority in reducing anterior knee pain following ACL reconstruction

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Abstract Arthroscopically-assisted ACL-reconstructions are currently reliable, reproducible. Residual anterior knee symptoms however, especially after patellar-BTB graft use, are not uncommon occurrences. Contributing factors are numerous and include injury to the saphenous nerve infrapatellar branches and/or histologic changes at the harvest site. The use of mini invasive harvesting technique decreases the risk of injury to the saphenous nerve infrapatellar branches while preserving the peritenon. The double-incision approach significantly reduces the mid-term incidence of anterior knee pain after ACL-reconstruction. Additionally, this technique markedly decreases the occurrence of sensory disorders and the extent of hypoesthesia. We thus advocate the use of a double-incision graft harvesting technique in ACL-reconstruction using a patellar-bone-tendon-bone transplant.

Keywords Anterior cruciate ligament reconstruction · Bone tendon bone graft · Anterior knee pain · Saphenous nerve · Mini invasive technique

Introduction

Current concepts of anterior cruciate ligament (ACL) reconstruction were originally described by Jones [1] in 1963 and gained widespread acceptance in the 1980s. These procedures have already reported satisfactory outcome regarding improvement of knee laxity.

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However, despite successful results, anterior knee pain is a common occurrence after bone tendon bone (BTB) reconstruction and can interfere with patient satisfaction An incidence of 4 to 60% of anterior knee pain has been reported in the literature [2, 3]. Depending on pain severity, this condition might be either considered as a complication or a normal postoperative outcome. Moreover, dysesthesia, kneeling difficulties have been also reported

Anterior knee pain may have a large variety of causes, two of them being specifically related to bone-patellar tendon-bone graft techniques: injury to the infrapatellar branches of the saphenous nerve (IBSN) and inflammatory response related to the donor site healing process (tendinopathy).

Therefore, other graft choices have been used to reduce the donor site morbidity associated with patellar tendon grafts [4, 5 and 6], even if it has not dramatically decreased the incidence of pain or discomfort. However, due to its widely accepted advantages (high mechanical strength, reliable fixation), the patellar tendon graft remains a very popular option in ACL reconstruction.

Several technical improvements have been proposed to decrease the morbidity of BTB harvesting. Berg [7] and Liu [8] propose to suture the peritenon and to fill (as we do) the bone harvesting sites. But according to Kartus [9] and Brandsson [10], these proposals do not diminish the rate of post op anterior knee pain.

In order to prevent IBSN while preserving the peritenon, which improves the tendon healing process, mini invasive techniques have been proposed [11••, 12–14], which allow to harvest the bone patellar tendon bone graft without tearing peritenon, and the majority of neural branches. All these authors propose a double incision (vertical or horizontal)

Anatomy

Many anatomic studies have evaluated the course of the saphenous nerve in the anterior knee region [15–20]. In our own anatomical study [13, 15] on 18 cadaver knees, we harvested BTB graft using double incision technique and then exposed the anterior aspect of the knee in order to assess the anatomy of the saphenous branches and the eventual injuries of these branches

We found the following results:

– there were 2 branches in 12 cases (Fig. 1a) and 3 branches in 6 cases (Fig. 1b)
– the mean distance between the tip of the patella and the proximal branch was 21.9 mm (15–30 mm)
– the mean distance between the more distal branch and the top of the anterior tibial tubercle was 16.2 mm (0–27 mm).
– All the branches were located between the distal part of the proximal incision and the proximal part of the distal incision.
– In 15 cases there were no neural tear. In 2 cases, distal branch was torn . In 1 case proximal branch was torn through the antero medial arthroscopic portal (Fig. 1b) [20]
– Among a total of 42 branches, only 3 were torn. Distal branch is at risk
– Peritenon was always preserved (Fig. 1a)
– BTB graft was always consistent

This technique is technically feasible and preserves peritenon and neural branches

Operative technique

Patient positioning is as usual. Graft harvest is carried out with the knee placed in 90° of flexion. Two vertical incisions, twenty millimetres in length, are made (Fig. 2). The proximal incision doesn't go below the tip of the patella while the distal incision is centred on the anterior tibial tubercle [13, 14]. Tsuda et al. [12] advocate the use of horizontal incisions and dissection of retaniculum. Horizontal incisions would decrease the risk of potential injury to neurologic structures and provide improved surgical access to the tendon width and tibial tunnel. According to Mishra et al. [21], horizontal incisions would also result in a more satisfactory cosmetic appearance. Tsuda [12] and Mishra [21] do not report any wound complication. However, just like Kartus et al. [11••], we advocate the use of a vertical incision to facilitate its re-use in case of later surgery.

Subcutaneous tissue is incised on the patella and ATT. Metzenbaum scissors are passed subcutaneously from the proximal to the distal incision between the peritenon and the anterior aspect of the patellar tendon. The mid third of the tendon is then dissected, using either a specific double bladed stripper (9 mm for female or 11 mm for male) or simply a Ethibond suture which acts from proximal to distal as a Gigli saw through the tendon. The patellar tendon fibres are split longitudinally from the patella to the anterior tibial tubercle insertion. A 20 mm×10 mm patellar bone block, interdependent from the patellar tendon, is then harvested using an oscillating saw blade (Fig. 2b). Patellar graft is released from Hoffa's ligament using Metzenbaum scissors which are introduced in the proximal incision. A Kelly forceps is

Fig. 1 Cadaver study. **a** Left knee; example of two infra patellar branches. Mini invasive technique allows to preserve infra patellar saphenous branches and peritenon. **b** Left knee : example of three infrapatellar saphenous branches. The proximal branch is at risk through the arthroscopic infra medial portal. The distal branch which runs just at the top of the ATT, is at risk through the distal approach. (From Drain, et al. [13]; with permission from Elsevier)
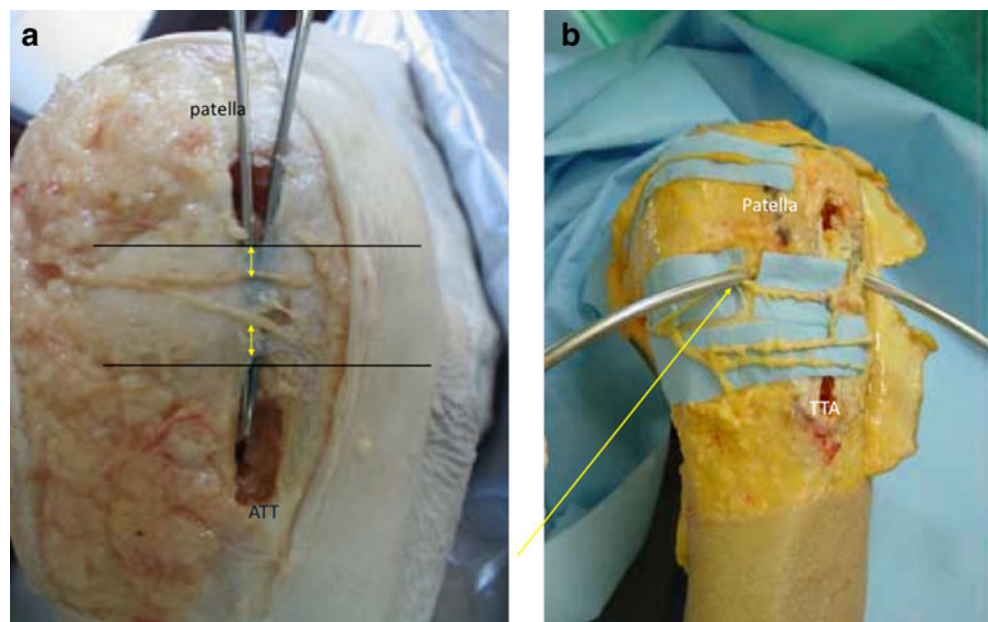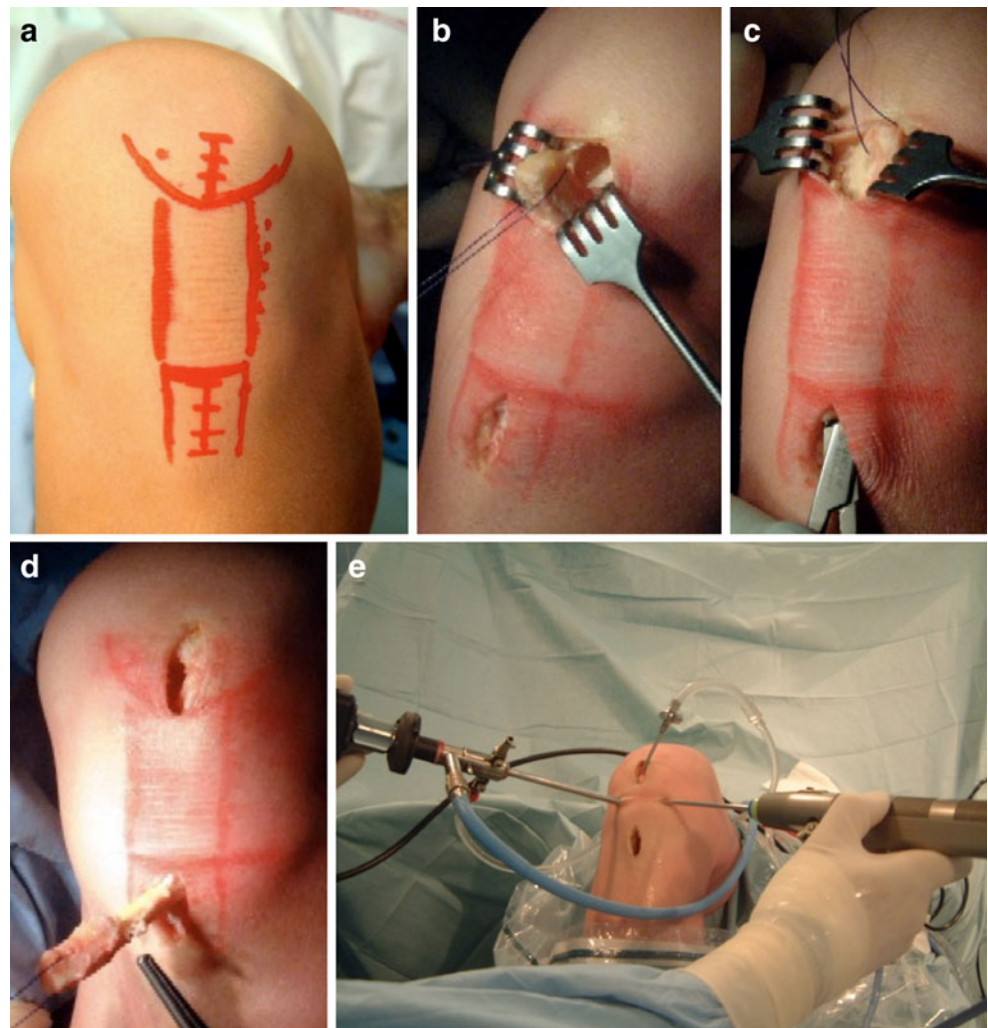
Fig. 2 A two-incision graft harvesting approach. **a** The incision landmarks are drawn on the skin. **b** The patellar bone plug, armed with a thread, is harvested. **c** The peritenon layer is separated from the patellar tendon. The patellar bone plug is held with Kelly forceps. **d** The patellar bone plug and mid-third of the patellar tendon are drawn towards the tibial incision. The tibial bone plug is then harvested. **e** Arthroscopy is then performed via standard approaches

passed between tendon and peritenon from tibial to patellar incision allowing extraction of the patellar bone block through the tibial incision (Fig. 2c). The oscillating saw is then used to cut a 20 mm long tibial bone block (Fig. 2d). The bone-tendon-bone graft is thus harvested via this double-incision approach. The standard infero-medial and infero-lateral arthroscopy-assisted approaches are carried out (Fig. 2e). It is possible to create the inferolateral approach through the proximal incision. For the infero medial approach, we use an horizontal incision to minimize the risk of nerve damage. Both tunnels are created independently. The tibial tunnel is created through the distal incision. The femoral tunnel is created via the infero medial portal.

Results

Goals of this technique are:

– to diminish post op anterior knee pain
– to diminish hypoesthesia and dysesthesia

– to improve ability to kneel (kneeling test or knee-walking test)

Standard incision BTB reconstruction versus Hamstrings reconstruction

In the Frnch Arthroscopy Society (SFA) retrospective series (136 BTB and 122 hamstrings with a minimum follow up of 18 months) reported by Gaudot [6] and specifically devoted to anterior knee pain (AKP), AKP is more frequent in the standard harvested BTB group (33%) than in the hamstring group (25%), but the difference is not significant. This absence of difference is also reported by Eriksson et al. who studied randomly 84 BTB and 83 hamstrings [4].

Patello femoral score is <90 in both groups in the SFA's study. Subjective IKDC score is better in the BTB group ($p=$ 0.04). The level of pain is statistically less in the BTB group ($p=0.04$) where the location of pain strictly corresponds to the tip of the patella and the patellar tendon. In the hamstring group, it is located more medially.

Ability to kneel is much more difficult in the BTB group than in the hamstring group [4–6]

Hypoesthesia is more important after BTB reconstruction than hamstring reconstruction ($p<0.0001$)

Standard BTB versus mini invasive BTB harvesting

We reported a prospective comparative study, of 19 single standard incision technique and 21 double incision mini invasive technique (mean follow up: 32,7 months). Both groups were comparable in terms of age, time to surgery, pre op status, etc.…

The clinical diagnosis of AKP was based on patient's positive response to the question: "Is your anterior knee painful?" Pain severity was not interpreted by the examiner. In all cases, pain and subjective hypoesthesia items were recorded prior to knowing whether single or double-incision approach had been performed.

The examination form included:

- Pain-related items (cause of trauma, type of surgical approach, associated procedures, postoperative analgesia, postoperative patient's satisfaction, immediate complication, algodystrophy).
- At last follow-up: Pain assessment (anterior knee pain and/or other pain, severity, evolution, pain location, Lille patello-femoral rating system [22], objective specific tests; analysis of sensorial disturbances (localization, type, extent on mapping), functional assessment (IKDC), quality of life assessment (SF36), radiographic and sonographic investigations.

A transparent overlay featuring a centimetric grid (Fig. 3) was placed over the knee to determine the area of sensory disorder; scars were transferred and area of the sensory disorder was drawn. The results according to each group are shown in Table 1.

The double-incision sub-group showed a significant decrease in pain frequency but not in pain severity when compared with the single-incision sub-group (19% versus 58%; $p=0.01$). the global rate of pain was 37.5% which strongly corroborates the findings of previous studies [23–26] incidence of sensory disorders was lower ($p=0.002$) while involving a smaller surface area (4.9 cm2 vs 11.5 cm2; $p<0.03$). The knee-walking test was significantly better in the double-incision sub-group ($p<0.02$). No significant differences could be detected from the results of the patello-femoral, IKDC subjective and objective scores. SF36 scores were analyzed either by comparing both group results or by comparing the whole series data with French normal ranges according to age and gender. No significant differences were observed.
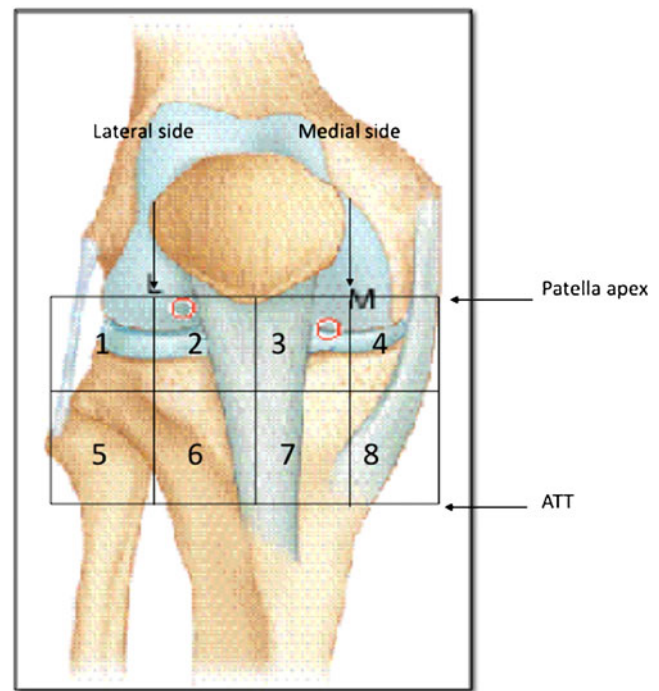

Fig. 3 A transparent overlay featuring a cm grid is placed on the knee to measure the are of hypoesthesia. (From Gaudot, et al. [14••]; with permission from Elsevier)

No statistically significant correlation between occurrence of anterior knee pain and presence of sensorial disturbance was detected ($p=0.39$). Furthermore, there was poor correlation between anterior knee pain and extent of sensorial disturbance ($p=0.52$). However, relationship between knee-walking test results and extent of hypoesthesia could be established. The surface area of hypoesthesia had an average of 10.34 cm2 in patients with abnormal test results and 3.78 cm2 in those with normal test results ($p=0.035$).

Patellar height was identical in both groups reporting a Caton and Deschamps index [27] of 0.99 for the double-incision sub-group (range 0.68 to 1.30) and 0.99 for the single-incision sub-group (range 0.81 to 1.29).

Seventeen patients (10 double-incisions and 7 single-incisions) were assessed ultrasonographically at a mean follow-up of 28 months (range 22 to 32) (Table 2). The patellar tendon donor site defect was significantly thicker than the contralateral one ($p<0.0001$). Mean tendon thickness value was compared according to the surgical approach and the pain-free or painful status of patients. Tendon thickening was less obvious in the double-incision sub-group although ultrasonographic measurements failed to show a statistically significant difference between the two groups. We searched for correlation between anterior knee pain and tendon thickening value:

- nine pain-free patients had a mean thickening value of 0.193 cm2;

Table 1 Results according to the approach

		Single-incision (*n*=19)	Double-incision (*n*=21)	Level of significance (p)
Anterior knee pain		58%	19%	*p*=0.01
Pain severity (range 0–10)		1.9/10	2.4/10	NS
Pain location	Patella	5	1	NS
	Tendon	4	2	
	Anterior tibial tubercle	2	1	
Hypoesthesia		17	9	*p*=0.002
Hypoesthesia surface area (cm2)		11.5	4.9	*p*<0.03
Knee-walking test	Normal	3	11	*p*<0.02
	Unpleasant	13	8	
	Difficult	3	2	
Kneeling	No difficulty	3	8	*p*=0.24NS
	Mild difficulty	11	8	
	Moderate diff.	2	3	
	Severe difficulty	3	2	
Squatting	Possible painlessly	15	17	*p*=0.26NS
	Possible but painful	4	2	
	Impossible	0	2	
Patello-femoral score		90.8	91/100	NS
Weighted IKDC subjective score		84/100	85/100	NS
Objective IKDC	A	9	8	NS
	B	9	9	
	C	1	3	
	D	0	1	

(From Gaudot, et al. [14••]; with permission from Elsevier)

- eight painful patients had a mean thickening value of 0.390 cm2.

We did not consider this difference as being significant (*p*=0.08).

In our series, AKP incidence is thus lower in the double-incision sub-group (19%) than in the single-incision sub-group (58%) (*p*=0.01). Kartus et al. [11••] do not demonstrate any relationship. However, he uses different parameters for evaluation of AKP. (combination of the three following items: anterior knee pain with the knee flexed 90°+pain during stair climbing+pain during physical effort). Paradoxically, he reports an incidence of pain of 34% with the mini-invasive approach and 20% in the control group (non significant). Tsuda et al. [12] report a series of 75 patients subjected to a double-incision approach (follow up 35-month - no control group). AKP incidence is 17% which corroborates our results in the double-incision group.

In our series, we observe a significant difference between normal and abnormal knee-walking test in favour of the double-incision approach. Kartus et al. [11••] do not establish such correlation (*p*=0.07).

We do not observe any direct relationship between location of hypoesthesia and anterior knee pain, either from a qualitative or quantitative point of view, which contradicts Kartus et al's. observations [11••] and French Arthroscopic Societie's symposium [6] but corroborates Tsuda et al.'s findings [12]. However, extent of hypoesthesia and knee-walking test are correlated. Injury to the infrapatellar

Table 2 Sonographic results according to the approach

	Single incision *n*=7	Double incision *n*=10	*n*=17	Comparison single/double (p)
Surface area of donor site defect (cm2)	0.880	0.720	0.786 (0.440–1.34)	0.2
Surface area of contralateral tendon (control) (cm2)	0.547	0.467	0.500 (0.210–0.850)	0.38
Delta (donor site - control site) (cm2)	0.333	0.253	0.286 (0.40–0.840)	0.50

branches of the saphenous nerve is likely to induce functional impairment which reinforces interest in nerve preservation.

The double-incision approach significantly decreases the risk of anterior knee pain which is partly attributed to the preservation of the infrapatellar branches [11••]. However, the lack of difference between the patello-femoral scores and the absence of correlation with the area of hypoesthesia suggest that pain is not only related to nerve injury. Pain might also be attributed to the tendon itself. Peritenon protection through the double-incision approach appears to contribute to the tendon trophicity preservation.

Therefore, the double-incision approach preserves transplant quality and does not induce greater morbidity than the conventional method [5].

Ultrasonography has proved to be effective and reliable in the measurement of patellar tendon thickness [28]. Tendon thickening after graft harvest is documented by Berg et al. [29] and Wiley et al. [30]. Our series is the first one to compare the effect of two graft harvesting techniques on tendon thickening . Jarvela et al. [31] reviewed 31 patients at a mean follow-up of 10 years after reconstruction. Patellar tendon thickness was measured sonographically at its proximal and distal third. Patients with anterior knee pain reported greater tendon thickness than pain-free patients (5.6 mm versus 5 mm, the mean thickness of the healthy contralateral tendon was 4.2 mm). In our series, the coronal section was used for measurement of the mid-portion of the tendon via a computerised method. Although our results corroborate Jarvela's findings, it does not appear significant enough.

Conclusion

Double-incision approach reduces the mid-term incidence of anterior knee pain as well as the incidence and surface area of hypoesthesia. Preservation of the infrapatellar branches of the saphenous nerve and better tendon trophicity through preservation of peritenon thus provide strong evidence for efficiency and reliability of the double-incision approach.

Furthermore, the double-incision approach does not compromise the quality of reconstruction.

We advocate the use of a double-incision graft harvesting approach in bone-patellar tendon-bone ligament reconstruction. This approach is routinely performed in our department.

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