Original Article

Anterior knee pain in ACL reconstruction with BPTB graft – Is it a myth? Comparative outcome analysis with hamstring graft in 1,250 patients

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ABSTRACT

Anterior Knee Pain (AKP) has been quoted as the main disadvantage of Bone Patellar Tendon Bone (BPTB) graft in Anterior Cruciate Ligament Reconstruction (ACLR). We overcome the problem by harvesting BPTB graft by mini-open mobile window technique.

Objectives: To investigate postoperative incidence of AKP with BPTB graft in comparison with hamstring graft during primary ACLR.

Methods: Total of 1737 patients underwent ACLR in the study period of which 1250 met eligibility criteria (622-BPTB graft, 628-Hamstring graft).

Results: Incidence of AKP, Lysholm score and IKDC score were analysed and found no statistically significant difference at 18-month followup.

Conclusion: BPTB graft harvested by mini-open mobile window technique has a low incidence of AKP as of hamstring graft.

1. Introduction

Anterior cruciate ligament (ACL) is the most commonly injured ligament of the knee. The goals of the ACL reconstruction (ACLR) are to restore stability to the knee and prevent recurrent injuries to the articular cartilage. The preferred graft choice in decreasing order of preference is hamstring tendon (HT) graft followed by bone-patellar tendon-bone graft (BTP/BPTB), allograft and quadriceps tendon graft according to various sources.^{1–3} Both BPTB and hamstring tendon grafts have been widely used and studies have shown differences between the two graft types in terms of outcomes, retear rates, and complication rates.^{4,5} Choosing the right graft for the patients often depends on the surgeon's preferences. Both BPTB and HT autograft have unique complications relating to graft harvesting.⁶

BPTB graft provides bone to bone healing, better rotational stability and reliable fixation. It remains the gold standard as far as mechanical stability and early return to high level sports is concerned.⁷ Most articles in the 1990s quote anterior knee pain (AKP) as the main drawback of BPTB autograft with an incidence of up to 40%.^{8–10} AKP following BPTB harvesting has several etiologies: more frequent bone-harvesting site

pain, neuroma due to infrapatellar branch of medial saphenous nerve lesion and rarely patellar tendinopathy.¹¹ Biedert et al. found that free nerve endings are more concentrated in patellar tendon, retinacular tissues, pes anserinus and particularly in synovial tissues and fat pad.¹² Extensive soft tissue dissection and injury to these structures can lead to AKP. Hence there was a shift to other soft tissue graft options mainly the Hamstring graft. However, in recent times, with a better understanding of the pain generators and improvements in surgical techniques, there has been a resurgence of the BPTB graft.^{13–15}

To decrease the graft site morbidity of the BPTB technique, several authors have described different solutions.^{16–20} Among which less invasive graft harvest is the most common strategy. The authors in this study utilized a mini mobile window harvest technique to decrease the incidence of anterior knee pain. In this modified surgical technique, a small skin incision was mobilized up and down by utilizing different ranges of knee flexion to harvest patellar and tibial bone plugs. We hypothesized that the incidence of postoperative anterior knee pain and functional outcomes in patients undergoing ACL reconstruction (ACLR) with patellar tendon autograft using our harvest technique is no different from that of hamstring graft.

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This study aimed to investigate the postoperative incidence of anterior knee pain with bone tendon-bone (BPTB) graft in comparison with hamstring graft in patients who have undergone anterior cruciate ligament reconstruction.

2. Materials and methods

This prospective, non-randomised, single-center study was carried out between January 2012–December 2015 following approval from the institutional ethics committee/Institutional review Board. A total of 1737 primary ACL reconstructions were performed during that time frame, of which 1250 patients met the eligibility criteria. **Inclusion criteria:** Skeletally mature individuals, timing of surgery atleast 6 weeks from the date of injury, and Unilateral surgery **Exclusion criteria:** Concomitant injury/Multiligamentous injury (like posterior cruciate ligament injury or collateral ligament injury or chondral or meniscal injury), pre-existing osteoarthritis of knee and previous knee surgery. Patients were allocated into two groups namely BPTB group (622 patients) and Hamstring group (628 patients) as described in the flow diagram (Table 1). The decision of choosing the appropriate graft for an individual was made by the surgical team considering the factors as mentioned in Table 2. All the patients provided consent to participate in

Table 2

Factors influencing the graft choice.

Bone Tendon Bone Graft	Hamstring graft
Skeletally mature younger individuals	Older individuals and non-athletic females
High-performance athletes and labourers involved in mechanical work	Sedentary and low physical activity jobs
Athletes involved Hamstring dependant sports eg. Sprinting, Hurdles, Gymnastics	Patients with Patella Alta or Baja, tendinitis

the study. Informed consent was obtained from all the participants involved in the study.

2.1. Operative technique

All the patients underwent the procedure under General anesthesia. Tourniquet was used. Diagnostic arthroscopy was done and ACL tear was confirmed and other concomitant injuries were noted. Then the planned graft was harvested as described below.

Table 1

Flow Diagram of Patient Inclusion, Exclusion and Follow-Up

Fig. 1. Intraoperative picture of a patient undergoing right knee arthroscopic anterior cruciate ligament reconstruction showing, a. Small oblique skin incision directed medially, b. Hook retractors applied to create a mobile window for graft harvest, c. Incision of the central third of the patellar tendon at 100–120° knee flexion.

Fig. 2. Intraoperative picture of a patient undergoing right knee arthroscopic anterior cruciate ligament reconstruction showing, a. Tibial bone plug harvest, b. Tibial bone plug with tongue.

2.1.1. BPTB group: BPTB graft harvest through mobile window technique (Figs. 1–4)

The Bone tendon-bone graft was harvested through a mobile window technique. Here a small oblique incision was utilized for harvesting the entire graft by mobilising the window in different ranges of knee flexion. With Knee in 30° flexion, an oblique skin incision of 4–5 cm (cm) was made over the patellar tendon directed medially (Fig. 1a). The dissection was carried out liberally through the subcutaneous tissue to enable free mobility of the skin. Then the incision was converted to a rectangular mobile window using retractors (Fig. 1b). The medial and lateral borders of the paratenon were visualised, paratenon incised. The middle one third patellar tendon incisions were made in 100–120° of knee flexion (Fig. 1c). This mobile window was moved distally over to tibial tuberosity at 30° of knee flexion to harvest tibial bone plug with the tongue (Fig. 2 a&b). Next, the mobile window is moved proximally over to patella with knee in full extension to harvest patellar bone plug (Fig. 3 a&b). The graft is delivered and the same incision was used to drill the tibial tunnel (Fig. 4a). BPTB graft was thus harvested using this technique (Fig. 4b). An optimised transtibial drilling technique for the femoral bone tunnel was performed. The graft was fixed with either a metal or bioabsorbable screws. The remnant bone chips removed from the graft were used to fill the patellar and tibial bone defects. Following which tight peritenon closure was done.

2.1.2. Hamstring group

The hamstring graft was harvested was done with a vertical incision over pes anserinus region in a standard manner. Quadrupled semitendinosus and gracilis graft were used in all patients. A transtibial drilling technique for the femoral bone tunnel was made. The graft fixation was done with the femoral endo button and metal or bioabsorbable interference screw at the tibia.

2.1.3. Postoperative rehabilitation

A standardised rehabilitation protocol began on the immediate postoperative period. It consisted of cryotherapy, full weight-bearing walking, patellar mobilisation, quadriceps, and hamstring isometrics, simple ankle pumps and single-leg raises. Postoperatively, the patients

were put on a knee brace for four weeks but the range of motion exercises was started ten days after the procedure. The patients underwent supervised physiotherapy sessions two times a week for the first six weeks after surgery. Further two sessions per month and then followed by one supervised session every month. The primary focus was on strengthening the quadriceps and hamstring muscles and achieving full extension of the knee. Jogging was allowed after four to five months, but return to competitive sports was restricted for a minimum period of six to nine months after surgery. Sports specific return to play assessments were done before clearance was given to participate in sporting activities.

2.1.4. Follow up of patients

Patients were followed up totally for a period of 18 months. The follow up intervals include, once a month for the first six months and thereafter once every six months. All measurements and clinical examinations were performed at three, six, and 18 months postoperatively. The IKDC subjective functional scores and Lysholm knee scores were calculated. The findings from the third month and 18 months follow-up visits were used for the analysis.

2.2. Statistical analysis

Statistical analysis was performed using SPSS software (Version 22, IBM, United States). For all tests, the level of significance was taken as p -value < 0.05 . The calculation between the difference of means was done by ANOVA, paired sample t -test and non-parametric test and those of frequencies by Chi-square test.

3. Results

Among 1250 operated patients who met the eligibility criteria, 42 patients were lost to followup (23 in the hamstring group and 19 in the BPTB group). Therefore a total of 603 (96.9%) and 605 (96.3%) patients in the BPTB and Hamstring group respectively completed the 18 months followup and were included for the final analysis. The demographic data and a comparison of the AKP, IKDC and Lysholm knee scores at three

Fig. 3. Intraoperative picture of a patient undergoing right knee arthroscopic anterior cruciate ligament reconstruction showing, a. Knee in full extension and mobile window moved caudally to access the patella, b. Pre-drilling for Patella bone plug harvest.

Fig. 4. Intraoperative picture of a patient undergoing right knee arthroscopic anterior cruciate ligament reconstruction showing, a. Delivery of the BPTB graft, b. Tibial and patellar end of the prepared BPTB graft.

and 18 months follow-up for both the graft types are detailed in [Table 3](#) and [Table 4](#).

During the final follow up, the percentage of subjects having anterior knee pain was similar in both groups ($p > 0.05$), with 41 patients (6.59%) and 39 patients (6.05%) in the BPTB and Hamstring groups respectively. There was no significant difference between the scores in both graft types at three and 18 months followup. The subjective IKDC score was 89.8% with BPTB graft and 90.4% with the hamstring graft (p -value 0.273). The Lysholm score for BPTB and Hamstring groups was 84.9% and 85.1% respectively (p -value 0.752). None of the patients required ACL revision. Thirty-eight patients in the BPTB group and twenty patients in the Hamstring group had superficial wound infection during the immediate postoperative period, managed by wound care and antibiotics. Two patients from the BPTB group required a relook arthroscopy and adhesiolysis was done due to flexion deficit ($>30^\circ$), followed by aggressive rehabilitation. Early extension deficit ($>5^\circ$) was noted in 124 patients who were conservatively managed. Delayed wound healing occurred in 16 of them who were managed by appropriate wound care.

Table 3
Demographic data and comparison of the outcome variables at three months follow-up.

At 3 months Followup	BPTB group	Hamstring group	P-value (significant if < 0.05)
Total number of cases	622	628	–
Lost to followup	–	–	–
Mean followup months (SD)	3.1 (1.1)	3 (0.9)	0.078
Mean age (SD)	29.7 (9.2)	30.9 (15.9)	0.103
Height (SD)	1.62 (1.7)	1.57 (2.1)	0.643
Weight (SD)	64.2 (12.7)	65.5 (13.3)	0.077
BMI (SD)	25.1 (8.1)	25.6 (6.2)	0.22
Anterior knee pain (%)	28.9	25.5	0.176
IKDC subjective score (SD)	54.1 (12.8)	53.6 (7.9)	0.405
Lysholm score (SD)	73.4 (9.2)	74.5 (11.7)	0.065

4. Discussion

This study demonstrates no difference in the incidence of AKP, as well as equivalent patient-reported outcome scores, were recorded in both BPTB graft using mini-open mobile window technique and Hamstring autografts in patients undergoing primary ACL reconstruction. The anterior knee pain incidence was comparable in both groups. Similarly, both groups showed improvement in the IKDC score and the Lysholm score at the last follow-up visit when compared with the initial postoperative status. These findings indicate the effectiveness of both procedures.

The incidence of anterior knee pain following ACL reconstruction has decreased in recent times due to various technical improvements as mentioned in [Table 5](#). In the present study, the incidence of AKP at three and 18 months (BPTB and Hamstring group) was 28.9% and 25.5% (p -value of 0.176) and 6.59% and 6.05% (p -value of 0.699) respectively. The differences were not statistically significant. We utilized a less invasive method where a relatively smaller (about 4 cm) was made instead of the traditional 7–8 cm incision.²¹ The use of this mini-mobile

Table 4
Demographic data and comparison of the outcome variables at 18 Months follow-up.

At 18 months	BPTB group	Hamstring group	P-value (significant if < 0.05)
Total number of cases	603	605	–
Lost to followup	19	23	–
Mean followup months (SD)	18.4 (3.2)	18.1 (4.6)	0.188
Mean age (SD)	28.9 (13.6)	29.5 (11.5)	0.407
Height (SD)	1.61 (2)	1.55 (2.1)	0.611
Weight (SD)	67.2 (12.1)	68.5 (13.7)	0.08
BMI (SD)	26.5 (4.4)	27.1 (10.1)	0.181
Anterior knee pain (%)	6.59	6.05	0.699
IKDC subjective score (SD)	89.8 (11.5)	90.4 (7)	0.273
Lysholm score (SD)	84.9 (11.6)	85.1 (10.4)	0.752

Table 5

Various techniques proposed to decrease the incidence of anterior knee pain following bone patellar tendon bone harvest.

Techniques Proposed	Authors/Studies
N	Several Researchers
<ul style="list-style-type: none"> Minimizing the bony and soft tissue trauma during graft harvest Preservation of fat pad Filling the bone defect with residual bone chips trimmed from the graft Meticulous closure of periteno Double incision technique/two transverse skin incisions to minimize soft tissue injury and to prevent injury to infrapatellar branch of saphenous nerve Minimally Invasive technique, performed using specific graft harvest instruments without incising the synovial bursa or paratenon. Harvesting a triangular bone plug (instead of rectangular shape) on the patellar side using two convergent incisions forming an isosceles triangle. Osteotomy was executed through specific points on patellar bone at 45° angle; during osteotomy, the deepest part placed in the triangles base and decreased in depth further from the base to head of the triangle Refilling the patellar and tibial bone defects with cored cancellous bone, obtained from the tibial tunnel and femoral socket using a coring reamer Application of a Beta-Tricalcium Phosphate Graft to Minimize Bony Defect in Bone–Patella Tendon–Bone Anterior Cruciate Ligament Reconstruction Use of plasma rich in growth factors/Platelet rich Plasma at the donor site after graft harvest 	Tsuda et al., ¹⁶ Kartus et al., ²³ Beaufils et al. ²⁴ Koh et al. ¹⁷ Sarzaem et al. ²⁵ Tsuda et al. ¹⁶ Agarwalla et al., ¹⁸ Kato et al. ²⁶ Seijas et al., ²⁷ Cervellin et al., ¹⁹ Walters et al. ²⁸ Mead et al. ²⁰
<ul style="list-style-type: none"> Collection of autologous bone fragments generated during reaming tunnels using a graft collection device, GraftNet (Arthrex Inc, Naples, FL) and augmenting with biologic agents such as PRP. This graft is used in addition to the larger bone graft derived from the bone plugs to fill the bone defects. Rehabilitation protocols focussed on obtaining optimum strength and full knee extension 	Shelbourne and Trumper, ¹⁰ Kartus et al. ²²
<ul style="list-style-type: none"> Use of mini-open mobile window technique - a small oblique skin incision was utilized for harvesting the entire graft by mobilising the window proximally and distally in different ranges of knee flexion thus minimizing the soft tissue dissection during graft harvest 	Current study

window technique reduces the soft tissue dissection and minimize the anterior knee pain. Reduced strength and loss of knee range of movements are correlated with AKP after ACLR using any kind of autograft,^{10,22} so efforts were taken during surgery and the rehabilitation for the patients in either group to regain complete knee range of movements and strength.

Subjective outcome scores are almost similar in both the groups, this finding is in accordance with the literature. Webster et al. in a RCT with 15-years follow-up showed that use of BPTB and Hamstring graft in ACL reconstructions had comparable results in terms of both subjective and objective outcomes.²⁹ Recent systematic reviews conducted by Chee et al.⁴ and Poehling-Monaghan et al.⁵ found no difference in the outcomes and re-rupture rates of the two groups (BPTB and HT) of autografts. However, those studies also found significant negative effects on the aspects of anterior knee pain, kneeling pain, and extension deficit.

The following are the limitations of the study. 1. The participants of the study are not randomised into two groups. 2. The lack of preoperative data makes it difficult to compare baseline IKDC and Lysholm scores. The impact that the graft choice had on the patient outcomes was not taken into consideration in the study. 3. Although the incidence of knee pain was studied, the quantification of knee pain was not done in this study. Documentation of Kujala anterior knee pain score or quantifying knee pain using a range of normal activities as described by Kovindha et al.³⁰ would be accurate for comparisons. 4. Lastly, this study lacks the blinding of patients and the surgeons. Hence, the possibility of assessment bias could not be excluded.

5. Conclusion

The BPTB graft, harvested by a mini-open mobile window technique has a similar incidence of anterior knee pain as in the hamstring graft. Anterior knee pain in BPTB harvest is merely a surgical harvest complication rather than the graft itself. Donor site morbidity with BPTB can be reduced with a refined mobile window harvest technique. Prospectively designed studies with a longer follow-up are recommended to establish the advantage of mini-mobile window technique.

Declaration of competing interest

None.

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