

# Functional outcomes of bone tendon bone versus soft tissue arthroscopic anterior cruciate ligament reconstruction

## A comparative study

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### ABSTRACT

**الأهداف:** مقارنة النتائج الوظيفية لاستعمال أسلوبين جراحيين معروفين لإستئناء الرباط التصالبي الأمامي ولمعرفة العوامل المؤثرة على تلك النتائج.

**الطريقة:** أجريت دراسة رجعية وذلك بإجراء الأسلوبين الجراحيين بقسم جراحة العظام، جدة، المملكة العربية السعودية على 34 مريض خلال الفترة من نوفمبر 2003م حتى فبراير 2011م على 34 مريض حيث استعمل الوتر الرضفي على 16 مريض وتم استعمال أوتار المايض على 18 مريض آخر. تم تجميع النتائج على فترة 3 أعوام ونصف في المتوسط ( $3.5 \pm 1.75$ ) بعد إجراء الجراحة (ما بين 7 شهور وسبع أعوام) مستعملين أحراز الركبة العالمية كما تم استعمال 18 سؤالاً صم خصيصاً لمعرفة أثر الجراحة على عادات ثقافية ودينية خاصة بالركبة للمجتمع المحلي.

**النتائج:** في المتابعة النهائية كانت متوسط درجات أحراز الركبة العالمية 82 في مجموعة الرضفي (BPTB) و 80 في مجموعة أوتار المايض (S-T). كان متوسط درجات مؤشر معيار WOMAC العالمي 71 في مجموعة BPTB و 65 في مجموعة ST. أظهرت الدراسة نتائج متقاربة للأسلوبين الجراحيين. عاد 21 مريض (61.8%) من مجموع المرضى لنفس مستواه الرياضي ماقبل الإصابة (47.6%) في مجموعة BPTB و 52.4% في مجموعة ST)، في حين عاد 27 من 34 مريض (79.4%) لنفس الوظيفة التي كان يشغلها قبل الجراحة (10 في مجموعة BPTB و 17 في مجموعة ST)  $p=0.021$ . لم يكن هناك فرق بين الأسلوبين الجراحيين فيما يتعلق بألم الركبة الأمامي أو بمشاكل المفصل الفخذي الرضفي  $p>0.05$ .

**خاتمة:** توصلت هذه الدراسة أن كلا الأسلوبين الجراحيين لهما نتائج مماثلة في شريحة المرضى المستعملة وأنهما لم يؤثرتا سلباً على العادات الثقافية من طرق الجلوس أو ثني الركبة في حالة الصلاة.

**Objectives:** To compare functional outcomes of anterior cruciate ligament (ACL) reconstruction using 2 graft techniques and to determine factors affecting these outcomes.

**Methods:** Thirty-four consecutive patients with ACL injuries surgically treated at King Abdulaziz University Hospital, Jeddah, Saudi Arabia between November 2003 and February 2011 were retrospectively assessed. Reconstruction was with bone-patellar tendon-bone autograft in 16 patients (BPTB group) and hamstring soft tissue autograft in 18 patients (ST group). Data were collected at an average of  $3.5 \pm 1.75$  years post-operatively, which included Western Ontario and McMaster Universities Arthritis Index (WOMAC) and International Knee Documentation Committee (IKDC) scores, and an 18 point questionnaire.

**Results:** The final mean WOMAC score was 82 in the BPTB group, and 80 in the ST group. The mean IKDC score was 71 in the BPTB group, and 65 in the ST group ( $p>0.05$ ). Twenty-one patients (61.8%) returned to their pre-injury level of activity after surgery (47.6% in the BPTB group, and 52.4% in the ST group) and 27 patients (79.4%) returned to the same job (10 in the BPTB group, and 17 in the ST group [ $p=0.021$ ]). No differences were noted between the 2 groups with regard to anterior knee pain, or patello-femoral symptoms ( $p>0.05$ ).

**Conclusion:** Similar outcomes were noted with similar numbers returning to sports. Concerns of anterior knee pain and patello-femoral symptoms associated with BPTB grafts did not affect outcomes related to cultural and religious functions.

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Knee complaints are extremely frequent in our population. In fact, knee pain may be one of the leading presentations to orthopedic clinics in the Kingdom of Saudi Arabia (KSA). In Western societies, the anterior cruciate ligament (ACL) is the most frequently ruptured knee ligament.<sup>1,2</sup> These injuries usually occur in younger patients, and have been shown to be a major risk factor for the development of future osteoarthritis.<sup>3,4</sup> Nonetheless, osteoarthritic changes have been noted even after ACL reconstruction.<sup>5</sup> The goal of ACL reconstruction is to restore stability of the joint, which in turn will reduce symptoms, improve functions, and allow patients to return to their pre-injury activities.<sup>6</sup> Many graft choices are available for reconstruction of the ACL. The most frequently used are the bone-patellar tendon-bone (BPTB) autograft, and the Hamstring double tendon soft issue (ST) autograft. Other graft choices have included but are not limited to, BPTB and ST allografts, Achilles tendon allografts and quadriceps allograft, or autograft as well as, tibialis anterior and tibialis posterior allografts. Table 1 summarizes the pros and cons of the 2 most frequently used autograft. Perhaps the most concerning of these qualities is the higher risk of anterior knee pain with BPTB autograft, which in our culture may be extremely significant since praying and kneeling represent an integral role in our daily activities.<sup>8</sup> Even though ACL injuries are extremely common in KSA, published research on our patient population is lacking. The incidence, prevalence, mechanism of injury and outcomes of ACL reconstruction in the Saudi population are unknown. In this study, our aim was to compare the functional outcomes after ACL reconstruction with BPTB autograft and ST autograft. Secondary outcomes included the determination of factors affecting these outcomes and the most common mode of ACL rupture. We hypothesized that functional outcomes measured by the Western Ontario and McMaster Universities Arthritis Index (WOMAC) and the International Knee Documentation Committee (IKDC) functional scores and return to pre-injury activities will be similar between groups.

**Methods.** *Search methodology.* Related research was used to develop our research question, and to

establish our primary and secondary objectives. Therefore, prior to initiation of this study a detailed search of the literature was undertaken. Two of the authors independently performed a Medline search using PubMed, Ovid, and EMBASE. The key words included anterior cruciate ligament, ACL, arthroscopy, hamstring, patellar tendon, outcome, and Saudi Arabia. Related abstracts from 1980-2012 were reviewed. Due to the restriction of using references published prior to 2002, those articles were reviewed but not used for the purpose of this study. Nonetheless, articles published in the Saudi population were used regardless of the year of publication.

*Patient selection.* Forty-two consecutive patients presenting with a clinical diagnosis of ACL rupture between November 2003 and February 2011 were included in this retrospective case control study. Patients' files were retrospectively reviewed after arthroscopic assisted ACL reconstruction, which was carried out by a single surgeon at the Department of Orthopedic Surgery, King Abdulaziz University Hospital, Jeddah, KSA. Patients were contacted to perform a final follow-up assessment as described below. Eight patients failed to respond, and hence were excluded from the study. Therefore, 34 patients were available for final follow-up. Between 2003 and 2007, the senior Orthopedic Surgeon performed all ACL reconstructions using BPTB tendon autograft. These included 16 patients. Due to the growing popularity of the ST autograft particularly in our city, and due to the rising concerns of the disadvantages of the BPTB autograft, the senior Orthopedic Surgeon changed his preferred choice of graft. Between 2008 and 2011 the senior surgeon exclusively performed ACL reconstruction using ST autograft on 18 patients.

*Data collection.* Approval from the Ethical Research Committee at our institute was granted based on international standards on conducting human medical research. All patient charts were reviewed and relevant data were extracted. This included patient demographics as well as details of their surgery and post-operative rehabilitation (Table 2). Patients were also contacted and asked to fill out both the WOMAC and IKDC questioners, as well as an 18-point questionnaire designed to address culturally relevant outcomes unique to the region (Appendix 1). This questionnaire was developed by the senior surgeon for this study and designed to standardize the questions and replies by the participants. Eighteen questions were written in English and Arabic, and all questions were answered under the direct supervision of a single author who insured the accuracy of the replies. Most importantly were the

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**Table 1** - Summary of the advantages and disadvantages of the 2 types of grafts used for anterior cruciate ligament reconstruction.<sup>6-9</sup>

Graft type	Male	Female
Bone patellar tendon bone	Faster incorporation and healing of the graft Strong insertion point	Anterior knee pain Patellar fracture Patellar tendon weakness or rupture <sup>6</sup>
Soft tissue	Smaller insertion	Longer healing time Hamstring muscle weakness

**Table 2** - Comparison of patient demographics and post-operative IKDC and WOMAC scores demonstrating no statistical differences between groups.

Variables	Bone tendon bone (N=16) Mean ± Standard deviation	In-patient (N=18)	P-value
<i>Gender</i>			
Male	15	18	
Female	1	0	
Age at operation (year)	22.1 ± 4.83	26.27 ± 4.07	
Age at follow-up (year)	27 ± 4.98	28.28 ± 3.89	0.408
Height (cm)	172.93 ± 7.24	171.65 ± 6.39	0.605
Weight (kg)	78.21 ± 17.89	80.57 ± 15.87	0.690
Body mass index	26.56 ± 5.92	27.3 ± 5.23	0.751
Time from injury to operation (month)	25.72 ± 35.27	22.61 ± 34.07	0.796
IKDC	71.21 ± 23.68	64.75 ± 20.16	0.403
WOMAC score	81.73 ± 21.82	80.44 ± 18.73	0.854

IKDC - International Knee Documentation Committee,  
WOMAC - Western Ontario and McMaster Universities Arthritis Index

questions on knee range of motion (ROM) and pain with respect to activities and praying normally. Pain was rated from 0 (no pain) to 10 (most severe pain), and this was explained by the investigator to each patient.

**Operative technique.** Apart from the graft choice and graft harvesting, the surgical technique was identical. After induction of anesthesia the patient received a first- or second- generation cephalosporin intravenously. The knee was examined under anesthesia, and the previous diagnosis of ACL rupture made by pre-operative magnetic resonance imaging (MRI) was also confirmed by a positive Lachman test and positive pivot shift. A well-padded pneumatic tourniquet was applied around the thigh, and the limb was prepped and draped in the usual sterile fashion. For the BPTB group, an anterior incision just medial to the patellar tendon was preformed and dissection was carried down to the patellar paratenon. A 10 mm strip of tendon was harvested from the central third of the tendon along with bone blocks from the proximal and distal insertions of the tendon. Care was also taken to avoid penetration deep to the tendon thus avoiding intra-articular penetration. The paratenon was then

closed using a running absorbable suture, and the graft was taken to the back table for preparation. For the ST group, the procedure started by placing the surgical limb in a figure 4 position. An antero-medial incision centered 5-7 cm distal to the medial joint line, and approximately 2-finger breadth medial to the tibial tubercle was preformed. The sartorial fascia was identified and a transverse incision along the superior margin of the gracilis tendon was performed. Care was taken to avoid injury to the infrapatellar branch of the saphenous nerve. At this point the semitendinosus and gracilis tendons were identified and a tendon stripper was used to remove the tendons after releasing the facial bands attaching them to the deeper structures. During this process, the superficial medial collateral ligament (MCL) was protected by avoiding deep dissection in the far medial area of this incision. At this point, the graft was taken to the back table for preparation and sizing by the assistant, while the surgeon began with a diagnostic arthroscopy. Associated injuries were identified and treated accordingly. The tibial tunnel was drilled under direct visualization to exit at the stump of the original ligament at the level of the anterior horn of the lateral meniscus in the midline. The guide wire for the femoral tunnel was then introduced using a transtibial approach and the entry point on the lateral femoral condyle was placed with-in the remaining stump of the native ACL when present. This was usually at the 10 o'clock position for the right knee, and the 2 o'clock position for the left knee. Tunnel size corresponded to the diameter of the graft. Fixation was performed using trans-fixation bioabsorbable pins placed percutaneously into the femoral tunnel using a guide, while the tibial side was fixed with an interference screw.

**Post-operative rehabilitation.** All patients were given a similar post-operative rehabilitation program. Patients were allowed only toe-touch weight bearing with a brace. Knee ROM was immediately allowed from 0-90 degrees. After 3 weeks, patients were allowed to weight bear as tolerated with crutches, and closed chain kinetic quadriceps strengthening was initiated. Patients then progressively worked on ROM and strengthening up to 3 months, at which point they started proprioception training and were allowed to run in a straight line. Contact sports were not allowed until after 6 month and only if they had full ROM and strength.

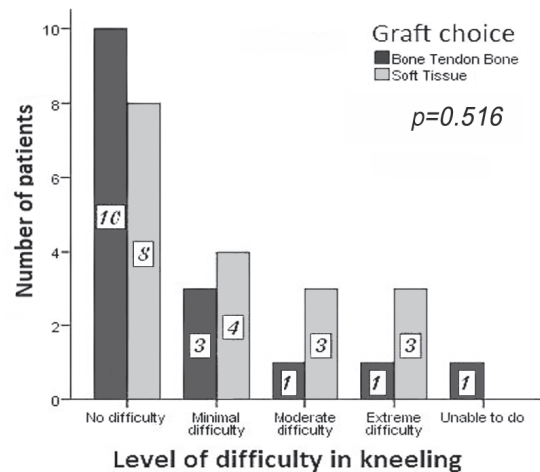
**Follow-up evaluation.** Patients were evaluated post-operatively at 2, 6, and 12 weeks, as well as, 6 and 12 month. Final follow-up was obtained from the chart. During each visit, the patients were asked regarding knee pain and symptoms of instability. Complications were recorded and physical examination was performed

to document knee ROM and stability, as determined by anterior translation of the tibia on the femur by using the Lachman and Anterior Drawer Tests. Finally, all patients were contacted by telephone to answer an 18-point questionnaire developed by the authors to address culturally pertinent issues. This included a pain severity scale as described above, and assessed the use of over-the-counter pain medications. It also assessed for difficulty in performing floor activities such as praying, kneeling, squatting, and sitting on the floor. Time to return to sports and pre-injury work activity was also documented. Patients were also asked to complete the WOMAC and IKDC scores at their final follow-up. This data was available for all 34 patients.

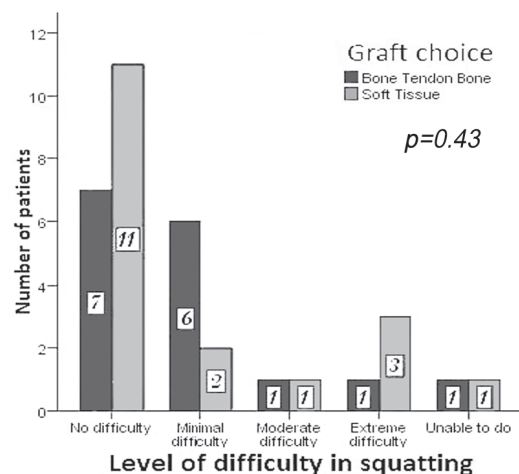
**Statistical methods.** The analysis was performed using the Statistical Package for Social Sciences version 16 (SPSS Inc, Chicago, IL, USA). Categorical data such as meniscal tear, use of painkillers, return to work and sport after surgery, and patient's satisfaction were compared using chi-square. Student's t-test was used to compare the means of demographic data and results of the IKDC and WOMAC between the 2 groups. Results were considered significant if the  $p < 0.05$ .

**Results.** Both groups were matched in their demographic data. In the BPTB group, the average age at surgery was  $22 \pm 5$  years, all were men except for one woman. The ST group comprised of only men with an average age of  $26 \pm 4$  years ( $p > 0.05$ ). Patients were followed up for an average of  $58 \pm 17$  months (range; 28-94) in the BTB group, and  $28 \pm 12$  months (range; 7-43) for the ST group ( $p = 0.000$ ). Football injuries were the most common cause of ACL rupture in our study population. Of the 34 patients, 28 (82%) sustained their injury during a football match. Two occurred secondary to motor vehicle collisions, 2 during falling, one patient sustained his injury while practicing Taekwondo, and one was secondary to direct trauma ( $p > 0.05$ ). Intra-operative findings of associated injuries included 7 medial meniscal tears and 4 lateral meniscal tears in the BPTB group, and 6 medial meniscal tears and 3 lateral meniscal tears in the ST group ( $p > 0.05$ ). The duration of surgery was  $149 \pm 35$  minutes (range; 108-246) for the BPTB group, and  $119 \pm 17$  minutes (range; 81-156) for the ST group ( $p = 0.003$ ). The length of hospital stay was also significantly higher for the BPTB group with an average  $2.9 \pm 1.6$  days (range; 2-5) compared to  $2.2 \pm 0.64$  days (range; 1-4) for the ST group ( $p = 0.022$ ). At an average 38-month follow-up (7 months to 7 years), the mean WOMAC score was 82 in the BPTB group, and 80 in the ST group. The mean IKDC score was 71 in the BPTB group and 65 in the ST group

( $p > 0.05$ ). Twenty-seven patients (79.4%) returned to the same job after surgery (10 in BPTB group and 17 in ST group [ $p = 0.021$ ]). Twenty-one patients (61.8%) returned to sports after surgery (47.6% in the BPTB group and 52.4% in the ST group). Return to sports was at an average of 8 months for the ST group, and 15 months for the BPTB group ( $p > 0.05$ ). There were no statistically significant differences between groups in the frequency and number of physiotherapy sessions attended, or in the duration of knee brace usage ( $p > 0.05$ ). Fourteen patients out of 19 (73.7%) who had participated in more than 16 physiotherapy sessions returned to sports. Whereas, only 7 out of 15



**Figure 1** - Comparison of means of anterior knee pain severity between the 2 groups during kneeling and Muslim prayers. There was no significant differences between the 2 groups ( $p = 0.516$ ).



**Figure 2** - Comparison of means of anterior knee pain severity between the 2 groups during squatting. There was no significant differences between the 2 groups ( $p = 0.43$ ).

patients (46.7%) return to sports when less than 16 physiotherapy sessions were attended ( $p>0.05$ ). With respect to knee pain, 5 patients from the BPTB group (31.2%) and 7 patients from the ST group (38.8%) were experiencing pain at final follow-up. This was rated on a scale from 0-10 (10 is the most severe) and was reported to be  $4\pm 3$  (range; 0-10) for the BPTB group, and  $5\pm 2$  (range; 0-8) for the ST group ( $p>0.05$ ). However, the use of occasional over-the-counter pain medications was higher in the BPTB group with 75% of patients in the BPTB group using pain medications compared to only 33% in the ST group ( $p=0.015$ ). The average return to normal Muslim prayers with kneeling properly was  $1.8\pm 1.4$  months (range; 0.5-6) for the BPTB group and  $2.4\pm 2$  months (range; 0.25-6) for the ST group ( $p>0.05$ ). No differences were noted between the 2 groups with respect to anterior knee pain or patello-femoral symptoms ( $p>0.05$ ) (Figure 1 and Figure 2). There were no re-ruptures of the ACL and only one complication was encountered. This was a superficial wound infection at the site of the rigid-fix insertion that occurred in a patient in the ST group. It was treated by dressing changes and oral antibiotics, and was completely healed at 4 weeks with sequelae.

**Discussion.** The ACL reconstruction has been extensively studied in the non-Middle Eastern cultures. Studies comparing different graft choices had demonstrated similar functional outcomes and subjective stability regardless of the graft choice. These have included randomized control trials,<sup>9,10</sup> and several meta-analysis.<sup>4,11-14</sup> These studies concluded that both BPTB autograft and hamstring autograft lead to similar functional outcomes with advantages and disadvantages to each graft choice. In particular, the issue of anterior knee pain and difficulty in squatting and kneeling associated with BPTB has concerned surgeons and patients alike in the Middle Eastern populations. Muslim prayers require us to kneel a minimum of 34 times a day, as long as we are physically able to do so. Any difficulty with performing normal Muslim prayers can significantly impact an individual's life. Furthermore, it is customary for these populations to perform many of their activities of daily living on the floor. In this study, we set out to compare the functional outcomes attained by both graft choices in the Saudi population, we also sought after the factors that had positive or negative impact on our patients. Published literature with regards to this subject for the Saudi population is scarce. A thorough search of ISI indexed articles comparing these 2 graft choices in the Saudi population returned no results. We were also unable to

find studies that specifically assessed outcomes of ACL reconstruction with respect to cultural and religious functions.

Khan et al<sup>15</sup> prospectively assessed 81 patients with knee injuries presenting to the emergency department in the Region of Asir. All were men with mean age of 35 (range; 20-60). They compared the utilization of ultrasound and MRI in diagnosing knee pathology in their patients and compared it to arthroscopic findings. The incidence of ACL injury in this cohort was 40%.<sup>15</sup> However, the true incidence of ACL injuries in the Saudi population is still unknown. Al-Husseiny et al<sup>16</sup> published a prospective study on press-fit fixation for ACL reconstruction using BPTP autograft in 42 patients in the Western Region of KSA. The mean age was 26 (range; 21-46) and all their patients' were men. Twenty-four patients (57%) sustained their injury during sports with football being the most likely cause of injury. Post-operative IKDC scores in this cohort was normal in 41%, nearly normal in 47%, abnormal in 10%, and severely abnormal in 2% of patients. Three of these patients required re-operation for flexion contractures, and one patient developed patellar tendonitis that required treatment with non-steroidal anti-inflammatory drugs.<sup>16</sup> Hasan et al<sup>17</sup> studied the effect of a brace-free rehabilitation program on the functional outcome of ACL reconstruction. This cohort was comprised of 85 men, with a mean age of 26 years (17-38). He compared 32 patients who underwent the "standard" rehabilitation program with 53 consecutive patients treated with a brace-free rehabilitation program. All were operated on, using a BPTB autograft similar to our technique. His results demonstrated superior clinical and subjective scores with the brace-free program.<sup>17</sup> Al-Othman<sup>18</sup> published on proprioceptive function after ACL reconstruction in a population of patients from the Eastern Region of KSA. He included 22 patients who had ACL reconstruction using BPTP autograft, and 32 patients with ACL deficient knees. The mean age of his patients was 27 years and all were male patients. Our study shared similar findings with respect to patient demographics. The mean age of our patients was 22 years for the BPTB group, and 26 for the ST group. With one exception all our patients were men, and the vast majority of patients sustained their injuries during a football game.

In a randomized control trial, Feller et al<sup>10</sup> found that that functional outcome scores measured by the Cincinnati knee scores and IKDC ratings, as well as the rate of return to pre-injury sports were not significantly different between the BPTB and ST groups. Freedman et al<sup>11</sup> in a meta-analysis similarly found no difference

in return to pre-injury level of sports. In their meta-analysis, Reinhardt et al<sup>14</sup> noted that outcomes were similar between groups when measured by the IKDC, Lysholm and Cincinnati scores. These studies, as well as another<sup>12</sup> have concluded that even though knee laxity, when measured objectively was higher in the ST group, patient satisfaction reported by outcome measures and return to sports was similar between groups. The results of our study are in keeping with these findings. We were unable to demonstrate differences between groups with respect to the WOMAC and IKDC scores and ability to return to the pre-injury level of sports. The 18-point questionnaire was developed in an effort to collect our data in a standardized manner, and to address certain points, such as time to return to sports and normal Muslim prayers, use of painkiller, and the severity of pain. This was used for the first time during this study and was not validated. This is a weakness that we acknowledge, nonetheless it served the purpose it was designed for. And to minimize variations in the replies by the participants, all interviews were conducted under the direct supervision of a single author.

Most studies comparing BPTB to ST autograft have noted higher morbidity associated with BPTB autograft, some have even reported higher re-rupture rates with the ST group.<sup>14</sup> We were unable to demonstrate this directly since the failure rate and complication rate was similar between groups. Nevertheless, this may have been demonstrated indirectly in our patient population by the fact that more patients returned to their pre-injury jobs in the ST group, and they were less likely to use over-the-counter pain medications than the BPTB group. On the other hand, the longer follow-up with the BPTB group may potentially bias our results since these patients may be complaining of pain secondary to the development of osteoarthritic changes.

A major concern with the use of BPTB autograft is the incidence of anterior knee pain and kneeling pain, which has been shown to occur more frequently with this group when compared to ST allograft.<sup>10-14</sup> We were unable to demonstrate significant differences in any of the culture specific parameter in our study population including the return to praying normally. Due to the retrospective nature of this study we were unable to specify time periods to which anterior knee pain may have contributed negatively. However, our questionnaire was specific enough to ascertain that even if anterior knee pain occurred with a higher frequency in the BPTB group it did not affect the patient's ability to return to praying and kneeling normally on the floor. This is extremely important since many surgeons in our region have abandoned the use of BPTB

autograft as their primary choice of graft fearing this complication. The longer follow-up in this group poses an inevitable limitation due to the design of the study. Nonetheless, the impact of this difference is buffered by the fact that many of the outcome measures were either collected prospectively during regular follow-up or were concerned with the time from surgery to return to specific activities and is not related to the duration of follow-up.

A secondary objective of this study was to determine the factors that may influence the outcomes of our patients. Since both groups were equally compliant with physical therapy and both had similar outcomes, we searched for factors that may have influenced the entire group of patients. The number of physical therapy sessions attended had a positive impact on the ability to return to sports. Sixteen sessions in particular affected our patients positively. This was demonstrated by the higher percentage of patients returning to sports (73.7% compared to 46.7%). And even though this was not statistically significant, one must consider the importance of the quality and duration of physical therapy after surgery. We also determined that the time from injury to surgery had no effect on the outcome of ACL reconstruction.

The retrospective design of our study is a potential weakness. However, most of the data analyzed was collected prospectively, hence minimizing bias. The relatively small numbers may potentially affect our results leading to type II error. On the other hand, the strength of our study is in our homogeneous study population that reflects the local population along with the important cultural and religious outcome measure. We have demonstrated that ACL reconstruction with BPTB autograft did not affect our patients' ability to pray, kneel, and sit on the floor. We established that the most common cause of ACL rupture in KSA was football, and that men are almost exclusively affected by this injury. We have also demonstrated that the knowledge presented by Western cultures, with respect to functional outcomes is valid for our patients.

In conclusion, we were unable to find significant differences in the outcomes attained by ACL reconstruction surgery using BPTB or ST allograft. Concerns of anterior knee pain and patello-femoral symptoms associated with BPTB grafts did not affect outcomes related to cultural and religious functions. Further prospective randomized studies would help affirm our outcome in this specific population.

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