

Cost Analysis of Outpatient Anterior Cruciate Ligament Reconstruction

Autograft versus Allograft

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Received: 1 March 2009 / Accepted: 12 November 2009 / Published online: 18 December 2009
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Abstract

Background Prior studies suggest the cost of allograft anterior cruciate ligament (ACL) reconstruction is less than that for autograft reconstruction. Charges in these studies were influenced by patients requiring inpatient hospitalization.

Question/purpose We therefore determined if allograft ACL reconstruction would still be less costly if all procedures were performed in a completely outpatient setting.

Methods We retrospectively reviewed 155 patients who underwent ACL reconstruction in an ambulatory surgery center between 2001 and 2004; 105 had an autograft and 50 had an allograft. Charges were extracted from itemized billing records, standardized to eliminate cost increases, and categorized for comparison. Surgeon and anesthesiologist fees were not included in the analysis. Groups were compared for age, gender, mean total cost, mean cost of implants, and several other cost categories.

Results The mean total cost was \$5465 for allograft ACL reconstruction and \$4872 for autograft ACL reconstruction. There were no differences in complications between the two groups.

Conclusions Allograft ACL reconstruction was more costly than autograft ACL reconstruction in the outpatient setting. The cost of the allograft outweighs the increased surgical time needed for harvesting an autograft.

Level of Evidence Level II, economic and decision analyses. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

ACL reconstruction is one of the most commonly performed orthopaedic procedures [5]. With advances in technique, the procedure has evolved from a largely open procedure to one that is completely arthroscopic. As a result, decreased perioperative pain and morbidity have caused a shift from this procedure being performed in an inpatient setting to one that now routinely is performed on an outpatient basis.

Third-party payers routinely reimburse a global fee for a procedure regardless of the way in which the procedure was performed, the type or number of implants that were used, or whether the patient required inpatient hospitalization. As a result, attempts have been made to improve and streamline perioperative efficiency, especially for procedures that can be performed in an outpatient setting.

Ambulatory surgery centers (ASCs) offer an alternative for performing outpatient procedures and have become very popular among physicians. Many orthopaedic surgeons routinely operate at an ASC and even may have a financial investment in one. As reimbursements for

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

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procedures continue to decrease, information regarding costs associated with procedures becomes important for the financial survival of a hospital, ASC, and an orthopaedic practice.

Based on a cost analysis of ACL reconstruction, Cole et al. concluded autograft ACL reconstruction resulted in higher mean charges [3]. In their study, a higher percentage of patients receiving autografts required inpatient hospitalization after the procedure. Given the difference in hospitalization rates after surgery, we presumed a similar cost analysis with all outpatient ACL reconstructions would yield a different result.

We therefore: (1) evaluated the mean total cost of allograft versus autograft ACL reconstruction in an outpatient setting; (2) assessed the effect of allograft cost versus autograft harvest time on the total cost; and (3) assessed differences in recovery room time and complication rates between the two groups.

Patients and Methods

We reviewed surgical logs from 2001 to 2004 for all ACL reconstructions performed by the senior author (SJL) at an ASC and identified 224 patients. We reviewed surgical operative reports and excluded all patients with major concurrent procedures (revision reconstructions, multiligament reconstructions, microfracture arthroplasties, and any meniscal work). These exclusions left 155 patients (105 autografts, 50 allografts) for the analysis. The autograft group included 94 bone-tendon-bone (BTB) cases and 11 hamstring grafts. The allograft group included 37 patellar tendon grafts and 13 Achilles tendon grafts. The allografts were obtained from one of two bone banks. All were fresh-frozen grafts. Both groups had the same gender breakdown (66.7% male in both groups). The mean age of the patients in the autograft group was 26.2 years (range, 18–58 years, 95% CI: 23.4–28.0 years) and the mean age in the allograft group was 38.1 years (range, 14–52 years, 95% CI: 35.2–41.1 years). We had a minimum of 1 year followup on all patients.

We extracted itemized cost billing sheets for these patients from the ASC computer database. Each item that could have been billed for was given a cost value based on the cost to the ASC. Each item was categorized for comparison. Graft cost was included in the total cost of implants. We calculated operating room (OR) and recovery room (RR) cost per minute of use and this was determined by multiplying the cost per minute by the number of minutes used. The cost per minute was determined by the ASC using factors such as rent, maintenance, equipment use, staff salary, and insurance. All values were based on the cost of the item as of January 1, 2001. As a result, all costs were normalized to the rate at the start of the study period. We reviewed

patient charts for the total intraoperative time and the total time spent in the recovery room as recorded by perioperative nursing staff. Charts also were reviewed for whether the patient received a block and for whether any complications occurred intraoperatively or postoperatively. All complications, including second surgeries, were documented.

All surgeries were performed by the senior author. For allograft reconstruction, a tourniquet was inflated to 250 mm Hg at the start of the case. Standard anterolateral and anteromedial portals were created. A diagnostic arthroscopy was performed and the ACL tear was documented. The allograft then was inspected and thawed. A notchplasty was performed to remove all remnants of the native ACL and create a wide notch to eliminate any graft impingement while an assistant trimmed the graft. An Arthrex (Naples, FL) ACL tibial drill guide was placed onto the ACL footprint with the angle on the guide determined by the length of the graft. A 3- to 4-cm incision was made over the proximal tibia down to bone for drilling the tibial tunnel. The guidewire was drilled retrograde and checked for satisfactory placement. After this, the reamer was drilled over the guidewire and the tunnel was cleared of all debris. The ACL Beath pin (Arthrex) then was drilled through a 7-mm over-the-top guide through the tibial tunnel into the 10 to 11 o'clock position on the medial border of the lateral femoral condyle in a position corresponding to the ACL footprint. The pin was drilled through the cortex of the femur and out of the skin proximally. The ACL reamer was placed over the pin and through the tibial tunnel and drilled retrograde into the femur. After drilling approximately 5 mm, the back wall was probed to assure proper integrity. The reamer then was advanced to a distance corresponding to the length of the femoral bone plug. Debris again was evacuated and the graft was passed retrograde through the tibia and into the femur. Metal interference screws were used in the tibial and femoral tunnels. The size of the screw was determined by the senior author during each case. The screwdriver for the femoral interference screw was placed through the tibial tunnel. After inserting the femoral screw, the knee was ranged through an arc of motion to check graft isometricity and for adequate superior and lateral notch clearance. The tibial interference screw was placed while applying a posterior drawer to the knee. The graft was probed for proper tensioning and for any possible sites of impingement. If an allograft Achilles tendon was used, a metal staple was placed at the edge of the tunnel over the graft to augment the tibial fixation and a bioabsorbable screw was used against the soft tissue portion of the graft in the tibial tunnel. The wounds were closed in a standard fashion, a sterile dressing was applied, and a knee brace locked in extension was placed on the extremity.

For autograft reconstruction, a tourniquet was inflated to 250 mm Hg at the start of the case. A 6- to 8-cm incision

was made just medial to the midline from the distal patella to just distal to the tibial tubercle. The incision was taken down to the paratenon of the patellar tendon. This was incised sharply and flaps were created to adequately see the medial and lateral borders of the patellar tendon. The tendon width was measured and a middle third section of 10 to 11 mm was incised sharply from the distal patella to the tibial tubercle. To mark out the bone plug the incision was made over the patella and the tubercle approximately 25 mm. A microsagittal saw then was used to cut out the bone plugs. After removal of the graft, an assistant sized and prepared the graft while the senior surgeon performed diagnostic arthroscopy and notchplasty. The surgery then was performed in the same manner as for the allografts. Metal interference screws were used for fixation.

Hamstring autograft reconstructions were performed by making a 3- to 4-cm midline incision along the proximal tibia. The tendon (gracilis or semitendinosus) was identified and harvested using a tendon stripper. The graft was fixed using a bioabsorbable interference screw on each end and augmented on the tibial side with a staple.

All cost variables for each patient were entered in a database worksheet (MS Excel; Microsoft, Redmond, WA) for statistical analysis. Patients were separated into two groups, autograft (patellar tendon or hamstring) and allograft (Achilles tendon or patellar tendon). We used the Student's t-test to compare groups with respect to operative time, recovery room time, total cost of procedure, total cost of implants, total cost of OR supplies, total cost of anesthesia supplies, and total cost of medications. Fisher's exact test was used to compare groups with respect to gender and complications.

Results

The mean total cost of allograft ACL reconstruction was greater ($p = 0.009$) than that for autograft reconstruction (\$5465 versus \$4872, respectively).

The mean total cost of implants and grafts (including graft cost, screws, and staples) was higher ($p < 0.001$) for the allograft group than the cost of implants for the autograft group (\$1106 versus \$113, respectively; $p < 0.001$). When the cost of the graft is removed, the cost for implants was similar ($p = 0.83$) between the two groups (\$114 for the allograft group versus \$113 for the autograft group) (Table 1). The mean total OR time for the autograft group was greater ($p < 0.001$) than that for the allograft group (110 minutes versus 97 minutes).

Total RR time was similar ($p = 0.22$) for the allograft and autograft groups (86 minutes versus 89 minutes, respectively). There was no difference ($p = 0.79$) in the complication rate between the two groups (4.0% for the

Table 1. Cost comparison and surgical time by graft type

Variable	Allograft (50)	Autograft (105)	p Value
Mean total cost	\$5465	\$4872	0.009
Mean cost of allograft	\$992	\$0	—
Mean cost of implants	\$114	\$113	0.83
Total operating room cost	\$3121	\$3512	< 0.001
Total recovery room cost	\$294	\$306	0.19
Total anesthesia cost	\$151	\$161	0.0167
Total operating room supplies cost	\$789	\$775	0.202
Total operating room time	97 minutes	110 minutes	0.007
Total recovery room time	86 minutes	89 minutes	0.19
Complication rate	4.0%	5.7%	0.79

allograft group and 5.7% for the autograft group). There were no infections in either group. The allograft complications included one patient who had a retear and one who had arthrofibrosis develop. The complications in the autograft group included three retears, two patients who had arthrofibrosis, and one patient who had a second surgery for a cyclops lesion.

Discussion

The American Board of Orthopaedic Surgery lists ACL reconstruction as the sixth most common procedure performed by candidates sitting for the Part II Oral Board Examination [5]. Factors that influence the cost of this common procedure should be identified. We therefore assessed the cost of allograft versus autograft ACL reconstruction performed in an outpatient setting. We questioned whether the cost of the allograft would outweigh the cost of increased surgical time needed for autograft harvesting. We assessed any differences in RR time and complication rate because this also would modify the cost.

We acknowledge several limitations to the study. First, given the retrospective nature of the study we relied on the accuracy of billing data and patient charts. However, these were the same billing sheets that were generated at the time of surgery and a prospective analysis would not have changed any billing practices. Second, we did not randomize patients into two groups. A randomized trial is difficult to do because age often factors into graft choice and could be a source of bias in any comparison of allograft to autograft ACL reconstruction. Third, we did not assess outcomes, return to work times, and number of physical therapy visits. Fourth, we did not include the cost of an ACL brace, continuous passive motion, or cryotherapy. At our institution, these items are handled by outside vendors and thus we were unable to attain their costs. These costs are

likely to remain constant because all ACL reconstructions at our institution, regardless of graft type, receive these appliances. Fifth, we had a limited sample size. However, because we were calculating the cost of surgical time, we chose to use a single-surgeon series to eliminate variability between surgeons. Sixth, we included only the cost of the surgical procedure and eliminated all cost increases during the study period. When comparing the total cost of a procedure, one also should include the cost of secondary procedures and complications, the cost of postoperative rehabilitation, the time lost from work, and the overall long-term outcome. We found no difference between the two groups with respect to complications and secondary surgeries and therefore assumed the cost of these complications and second surgeries to be similar. We identified no literature supporting differences in therapy visits or return to work when comparing different graft types for ACL reconstruction and our ACL postoperative protocol is the same regardless of graft type. Also, time to return to work is biased by the occupation of the patient. Despite this, our lack of inclusion of these parameters is a limitation. Standardizing the costs to the start of the study period is a limitation as this minimizes real-time differences in vendor pricing, rent, heating, staff salaries, and so on.

Benefits of this analysis include our focus on the cost of the surgery as opposed to using charges related to surgery. We used the actual cost of each item used and calculated the exact cost of OR and RR time. We believe this represents a more accurate assessment of the cost differential because charges often can be inflated. Finally, a cost analysis comparing two ways to perform a procedure can potentially influence medical decision-making if outcomes and complication rates are equivalent.

Some studies suggest outpatient ACL reconstruction results in lower charges [1, 2, 4, 7, 8, 10]. In this setting, our data show the cost of ACL reconstruction is influenced by the type of graft used. Bonsell reported use of a quadruple-strand hamstring graft decreased the charges by \$1015 compared with a BTB graft [2]. However, greater than 90% of the hamstring cases were performed by one surgeon and two surgeons used only BTB autografts. This introduces a bias that may reflect different techniques between these surgeons. Cole et al. found autograft ACL reconstruction was more costly than allograft [3]. In their series, all autografts were performed by two surgeons and all allografts were performed by one surgeon. This again may reflect a disparity in the technique and admission guidelines of the different surgeons because more patients receiving autografts required inpatient hospitalization, thus influencing overall charges. The current series was from one surgeon with all cases being performed in the same outpatient setting; the cost of the allograft outweighed the cost of increased surgical time needed to harvest an autograft.

We observed no difference in the time spent in the RR between the two graft types. However, a high percentage of our patients underwent postoperative femoral nerve blocks that assisted in their pain control and subsequent discharge home. Williams et al. reviewed a series of 948 patients undergoing outpatient ACL reconstruction with the use of a femoral nerve block for pain management [14]. They found the use of a nerve block reduced unplanned hospital admissions from 17% to 4% [14]. Nakamura et al. noted a higher RR stay for patients undergoing ACL reconstruction who received general anesthesia than for patients who received regional anesthesia [9].

We found no difference in complication rate at a minimum of 1 year after surgery. However, standardized laxity and pain measurements were not done, and outcome scores were not available. This is a limitation as detailed outcomes between the groups cannot be discerned in this analysis. Poehling et al. reported a 5-year followup of patients who had ACL reconstructions using either an Achilles allograft or BTB autograft [12]. They reported similar long-term outcomes between the two groups. However, the allograft group reported less pain and better short-term function but increased knee laxity at all times measured in the study [12]. Others have reported similar outcomes and complication rates between allograft and autograft ACL reconstructions [6, 11, 13]. If the retear rate were higher for one group, this obviously would change the total cost.

Our analysis shows a cost differential in ACL reconstruction influenced largely by the cost of allografts. This differential can be important because there is often a disparity between the reimbursement regulations between hospitals and ASCs for implants and allografts. As allograft use increases, and with the increase in biologics in orthopaedics, cost will be a major issue. Surgeons should continue to strive to advance science and provide their patients with the best possible chance at good outcomes regardless of cost. However, factoring in cost as a part of evaluating the benefit of a given procedure will assist surgeons in making the most cost-effective choice for their patients.

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