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Cost-effectiveness analysis: A key factor in selecting graft and its overall impact on primary ACLR

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Abstract
The utilization of cost-effectiveness analysis is of great significance within the field of orthopaedic surgery, as it enables informed decision-making by evaluating the relationship between treatment costs and patient outcomes. The selection of a graft for anterior cruciate ligament reconstruction (ACLR) is a pivotal factor in determining the efficacy of the surgical procedure and the subsequent results experienced by the patient. The choice of graft material, whether it is autograft or allograft, has a substantial impact on the results of surgical procedures. The selection process necessitates meticulous evaluation of various aspects, including the age of the patient, their level of physical activity, the availability of suitable grafts, and the expertise of the surgeon. The present article aims to critically review the economical clinical studies conducted for cost-effectiveness comparison between graft choice in ACLR. However, the selection of grafts in ACLR is an ongoing area of study, as there is currently no universally recommended graft that consistently produces optimal patient outcomes and satisfaction.
The studies identified in this review suggest that autograft options are more cost-saving as compared to the cost associated with allografts and the highly satisfactory patient outcomes with autograft use. Morever, the inclusion of value-added considerations can enhance the decision-making process for policymakers, healthcare practitioners, and decision-makers by providing them with more comprehensive information for resource allocation and treatment decisions.

Keywords: ACLR, cost-effectiveness, QALY, autograft, allograft.

Introduction
The anterior cruciate ligament (ACL), a central knee ligament that plays a key role in facilitating stability of the knee joint, limits anterior translation of the tibia over the femur in the sagittal plane [1]. An ACL tear is one of the most common sports injuries and leads to instability in the knee, which limits athletic performance [2]. The non-treatment of ACL tears results in meniscal injury ultimately leading to a risk of early degenerative disorders [3]. It is well established that a torn ACL does not heal with non-operative management, and surgery is necessary for a successful outcome [4]. Hence, ACL reconstruction (ACLR) is a gold standard surgical procedure for the treatment of ACL tear. Even though the procedure is performed at high frequency, there is a large variability in the choice of graft for ACLR. A good understanding of the biomechanics of the native ACL is crucial when choosing an ideal graft substitute for the reconstruction of ACL. However, the ideal choice of ACL graft remains a point of debate.
The grafts utilised for ACLR consist of autografts and allografts, which can be further categorised as irradiated and non-irradiate [5]. The utilisation of autografts, namely tendons harvested from the patient's own body, has emerged as the predominant approach for reconstructing the ACL. This procedure has garnered significant popularity within the medical community due to its favourable clinical outcomes, as evidenced by studies conducted by Buss *et al.* [6]. Another potential source of graft material is allograft tissue obtained from a deceased donor. These benefits encompass reduced operating durations, enhanced graft availability, decreased occurrence of postoperative arthrofibrosis, and expanded possibilities for graft selection [7]. Furthermore, allograft ACLR has the advantage of reduced donor site morbidity risk, as well as a decreased likelihood of complications such as anterior knee pain, loss of knee extension, and loss of knee flexion strength. The choice of grafts is influenced by several factors, including the surgeon's recommendation and expertise, the availability of grafts, the patient's level of physical activity, any pre-existing medical conditions, desired outcomes, and the patient's perception of the success and risks associated with different graft options. These perceptions may be shaped by exposure to media, literature, and anecdotal experiences of others.
In addition to the expanding array of treatment choices for primary ACLR, there is a concurrent rise in cost-conscious knowledge among orthopaedic surgeons. Cost-effectiveness plays a significant role in ACLR as it involves evaluating the balance between the costs associated with the procedure and the resulting health outcomes. So, the cost-effective analysis for graft choice in primary ACLR remains a matter of concern for both patients and surgeons. Cost-effectiveness in ACLR is important for healthcare decision-makers, including policymakers, insurers, and healthcare providers, to ensure that resources are allocated efficiently while delivering optimal patient outcomes. Furthermore, the utilisation of cost-effectiveness analysis plays a crucial role in providing valuable insights for healthcare policies, reimbursement determinations, and treatment guidelines. This aids in the pursuit of optimal value for money in various healthcare interventions, including ACLR and other relevant procedures. Limited research has been conducted to examine the expenses associated with primary ACLR across various hospital settings and populations. However, no

comprehensive evaluation has been undertaken to emphasize the significance of cost in determining the choice of graft for primary ACLR. This review emphasises the importance of integrating cost-effectiveness analysis into routine orthopaedic surgical procedures in sports, specifically ACLR using suitable graft materials. This review article is a synthesis of the economic clinical studies conducted to assess the comparative costs of surgical treatments related to ACLR.

1. Cost-effectiveness analysis (CEA) and its relevance in ACLR

Public health interventions are expensive and have broad benefits, but they are directed at populations or communities rather than specific individuals. Decision-makers in health care frequently face challenges related to ever-increasing costs of intervention which in return ensure good value in health care. An approach to address this encounter is to perform a cost-effectiveness analysis (CEA) that explicitly quantifies the relative costs and benefits of alternative interventions [8,9]. Decision-makers are given evidence-based information on the economic value of various actions through CEA. Decisions on which interventions to prioritize, which treatments to offer, and where to devote resources to obtain the best health outcomes within the available budget can be made using this information by policymakers, healthcare professionals, and patients [9]. CEA aims to potentially reflect the probable trade-offs and inform discussions of whether the proposed intervention (over an alternative) is worth the additional gain in health produced by it. Moreover, healthcare resources are limited, and CEA helps prioritize the allocation of resources to interventions that provide the most value for money. By identifying interventions that are both effective and cost-effective, healthcare systems can optimize resource allocation and ensure that resources are used efficiently to maximize health outcomes [10]. Therefore, cost-effectiveness research methods incorporate measurements of change in health-related quality of life after medical intervention, lifespan, and the cost of treatment thereby providing insights into the value of different healthcare interventions and treatments.

Within the realm of orthopaedic procedures, knee ACLR ranks as the sixth most often conducted surgical surgery. According to Stewart *et al*. [11] a cost-effectiveness analysis (CEA) was conducted to assess the treatment options for acute ACL injuries, including initial surgical reconstruction and physical therapy. The study indicated that ACL reconstruction was a more cost-effective approach when compared to physiotherapy or no reconstruction, particularly in competitive athletes. The findings of the above-mentioned study were based on the incremental cost-effectiveness ratio (ICER) compared between ACLR and physical therapy. Some key factors considered in a cost-effectiveness analysis of ACLR include parameters such as costs of ACLR, alternative treatment costs, health outcomes, long-term outcomes, and quality-adjusted life years (QALYs) (Figure 1). The procedure of using grafts to repair ACLR results in significant costs for the health care system. ACLR costs have also been found to be highly variable and this variability stems from the surgical fixation techniques and graft options available for ACLR. Factors such as graft source, operation room (OR) supply use, and OR time all play a contributory role in building up the cost of ACL reconstructive procedures.

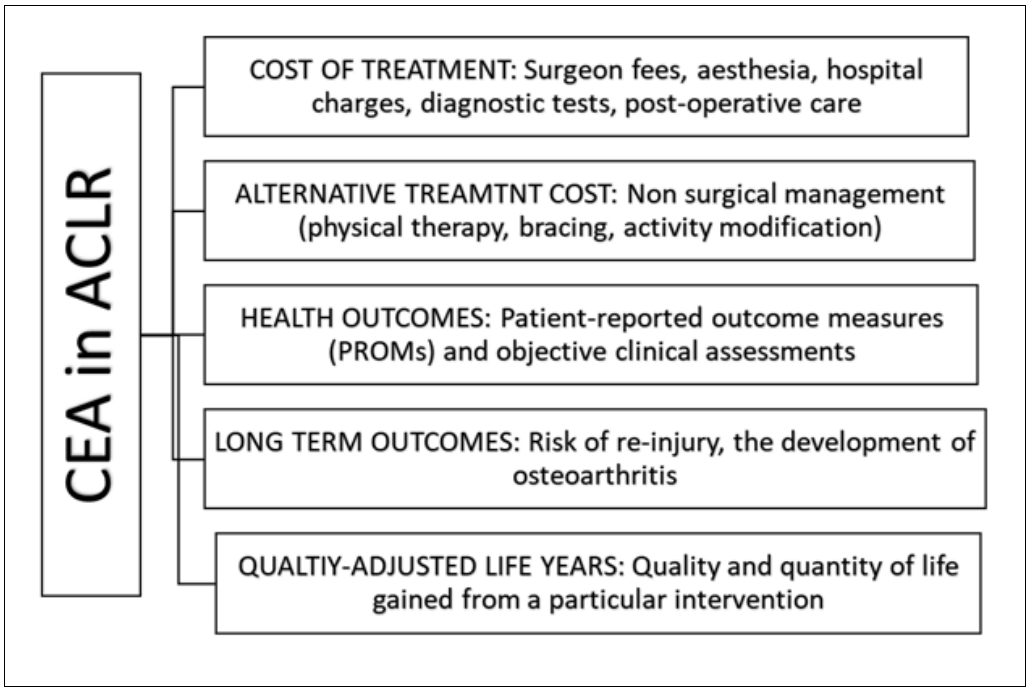

Fig 1: Key factors considered in a cost-effectiveness analysis of ACLR

Existing cost-effectiveness studies on graft choice in ACLR

Anterior Cruciate Ligament Reconstruction (ACLR) graft selection is influenced by several variables, including the patient's characteristics, the surgeon's preferences, the range of graft alternatives, and the desired results. Numerous Studies were performed in the past which compared the choice of graft employed in primary ACLR using tools of CEA (Table 1). However, there are scarcity of reports that compare the cost of primary ACLR based on the graft choice.

Table 1: Selected economic studies on ACLR comparing Autograft vs. Allograft [17]

S.no.	Study	Type study	Patients	Age range (Years)	Intervention		Graft allocation		Cost		Cost-effective	Conclusion
					Autograft	Allograft	Autograft	Allograft	Autograft	Allograft		
1.	Cole *et al*., 2005	Prospective, nonrandomized trial	122	15 to 45	BPTB	AT	86	37	Total expense: $5694 Day hospital cost: $314 +/- 111 Surgical center cost: $912 +/- 164 Pharmacy cost: $1139 +/- 370 Anesthesia cost: $917 +/- 197 Anesthesia supplies cost: $121 +/- 56 Radiology cost: $123 +/- 157 OR supplies: $1534 +/- 452* PACU cost: $254 +/- 104* Laboratory cost: $18 +/- 52* Central supplies cost: $16 +/- 18 Respiratory care cost: $15 +/- 9 Cast room cost: $252 +/- 163 "Other" cost: $79 +/- 30	-Total expense: $4622* Day hospital cost: $26 +/- 88* Surgical center cost: $617 +/- 100* - Pharmacy cost: $677 +/- 765* Anesthesia cost: $558 +/- 111* Anesthesia supplies cost: $99 +/- 32* Radiology cost: $36 +/- 42* OR supplies: $1818 +/- 275 PACU cost: $410 +/- 108 Laboratory cost: $36 +/- 42 Central supplies cost: $11 +/- 20 Respiratory care cost: $14 +/- 7 Cast room cost: $244 +/- 135 "Other" cost: $76 +/- 24	Allograft	Autograft BPTB was much more expensive than allograft ACLR, making allograft ACLR a more affordable option for autograft reconstruction.
2.	Nagda *et al*., 2010	Ambulatory surgery center	155	18–58 (autograft) 14–52 (allograft)	BPTB and HS	PT and AT	105 BTBP (94) + HS (11)	50 PT (37) + AT (13)	Total cost: $4872* Implant cost: $113 OR cost: $3512 RR cost: $306 Anesthesia cost: $161 OR supplies cost: $775	Total cost: $5465 Allograft cost: $992 - Implant cost: $114 OR cost: $3121* RR cost: $294 Anesthesia cost: $151* OR supplies cost: $789	Autograft	In the outpatient context, allograft ACLR was more expensive than autograft ACLR; the cost of the allograft outweighed the longer surgical time required to harvest an autograft.
		Retrospec		13 to 47					Total cost:	Total cost:		The lower

3.	Cooper *et al*., 2010	tive study at large academic medical center	98	(autograft) 15 to 59 (allograft)	HS	AT	49	49	$5195 OR cost: $1636 RR cost: $428* Anesthesia cost: $492 Pharmacy cost: $38 OR supplies cost: $2605	$4072* OR cost: $1721 RR cost: $511 Anesthesia cost: $491 Pharmacy cost: $40 OR supplies cost: $1309*	Autograft	operating and RR expenses did not make up for the increased cost of employing an allograft for ACLR in a high-volume, skilled surgical team.
4.	Barrera *et al*., 2011	Ambulatory surgery center	87	25.4 ± 9.8 (autograft) 25.4 ± 9.8 (allograft)	BPTB	BPTB	60	27	Total expense: $2983 +/- 508* Supply cost: $1715 +/- 487* Personnel cost: $237 +/- 59 Facility cost: $1030 +/- 258 Reimbursement: $2274 +/- 1285* Margin: $-208 +/- 1419 Total expense ("ACLR + meniscectomy"): $3309 +/- 872* Supply cost ("ACLR + meniscectomy"): $1967 +/- 855* Personnel cost ("ACLR + meniscectomy"): $251 +/- 62 Facility cost ("ACLR + meniscectomy"): $1091 +/- 268 Reimbursement ("ACLR + meniscectomy"): $3593 +/- 2201 Margin ("ACLR + meniscectomy"): $283 +/- 2044 Total expense ("Surgeons with > 12 ACLRs"): $3066 +/-	Total expense: $4283 +/- 852 Supply cost: $3132 +/- 794 - Personnel cost: $215 +/- 84 Facility cost: $936 +/- 365 Reimbursement: $3640 +/- 2298 Margin: $-644 +/- 2015 Total expense ("ACLR + meniscectomy"): $4041 +/- 1029 Supply cost ("ACLR + meniscectomy"): $2873 +/- 885 Personnel cost ("ACLR + meniscectomy"): $219 +/- 62* Facility cost ("ACLR + meniscectomy"): $950 +/- 270* Reimbursement ("ACLR + meniscectomy"): $3836 +/- 2364 Margin ("ACLR + meniscectomy"): $-205 +/- 2903 Total expense ("Surgeons with > 12 ACLRs"): $4078 +/-	Autograft	Autograft reconstruction was much less expensive than allograft ACLR.

									663* -Supply cost (“Surgeons with > 12 ACLRs”): $1852 +/- 637* Total expense (“Surgeons with <= 12 ACLRs”): $3458 +/- 766* Supply cost (“Surgeons with <= 12 ACLRs”): $1792 +/- 790*	928 Supply cost (“Surgeons with > 12 ACLRs”): $3045 +/- 856 Total expense (“Surgeons with <= 12 ACLRs”): $4325 +/- 992 Supply cost (“Surgeons with <= 12 ACLRs”): $2862 +/- 799		
5.	Gries *et al*., 2012	Hospital-Based Outpatient Setting	96	NA	HS	Soft tissue (anterior or posterior tibiali	50	46	Total cost: $3848.81 +/- 695* OR cost: $1983.68 +/- 343 RR cost: $384.29 +/- 174 Anesthesia cost: $347.72 +/- 63 Pharmacy cost: $102.77 +/- 20* OR supplies cost: $1030.34 +/- 97* Total reimbursement: $7005 +/- 1919 - Margin: $3156 +/- 1840*	Total cost: $4587.27 +/- 463 OR cost: $1428.10 +/- 233* RR cost: $334.05 +/- 96 Anesthesia cost: $274.35 +/- 55* Pharmacy cost: $128.65 +/- 19 OR supplies cost: $2422.13 +/- 195 Total reimbursement: $7835 +/- 1510* Margin: $3248 +/- 1287	Autograft	Shorter OR and RR times did not reduce the cost of the allograft tissue utilised in ACLR; however, in hospital-based outpatient settings, reimbursement covered the cost of the allograft, reducing the additional cost.

As per Cole *et al*. [12], 122 (bone–patellar tendon–bone autograft (n = 86) or freeze-dried achilles tendon allograft (n = 37) patients underwent ALCR in a prospective, non-randomized trial belonging to an average age group of 15 to 45 years. The choice of graft in the study was decided by the physician. The cost comparison performed in the above study estimated that the mean charge per allograft procedure was $4622 (range, $3874 to $6100) and per autograft (range, $4355 to $9691) was $5694. The cost escalation of $1072 was found with autograft ACLR as compared with allograft reconstruction. The predominant reasons for additional expenditures were mainly prolonged operating room (OR) time, anaesthesia time, and the cost of the overnight stay and consumption of post-operative medication However, there were a few limitations related to the study which cannot be overruled. The major limitations include the non-randomization of patients, the self-selection of surgeons by patients, and the surgeon’s preference for a particular graft choice or procedure. In light of the overall contributing elements, the authors came to the conclusion that allograft-based ACLR offered a promisingly less expensive option to autograft repair [12].

Nagda *et al*. [13] compared the cost analysis between allograft and autograft for primary ACLR in an outpatient setting. They retrospectively studied 155 patients (bone-tendon-bone (BTB) (94) + hamstring (HS) grafts (11) = 105 and patellar tendon (PT) (37) + Achilles tendon (13) allografts = 50) who underwent ACL reconstruction in an ambulatory surgery center between 2001 and 2004. The authors concluded that in an outpatient setting the cost of ACLR is influenced by the type of graft used. Based on their analysis, the mean total cost of allograft ACLR ($5465) was greater than that for autograft reconstruction ($4872). Additionally, the expense of the allograft outweighs the longer surgical time required for harvesting an autograft. The cost of the allograft ACLR is thus

determined by the graft price as well as the time spent in the OR [13].

Another study conducted by Cooper *et al*. [14] estimated the cost of ALCR using hamstring autograft (n = 49) or tibialis anterior allograft (n = 49) over 12 months (2004-2005) at a large academic medical center. The comparative study demonstrated that the total mean hospital cost for ACLR was $4072.02 for autograft and $5195.19 for allograft. Moreover, the cost of supplies was also higher for allograft whereas the recovery room (RR) cost was more for autograft. However, the cost of OR, anesthesia, and pharmacy was found to be non-significant in both the graft groups.. Ultimately, the study's findings indicated that the utilisation of an allograft for ACL restoration in the context of a proficient surgical team with a substantial caseload did not yield a cost benefit due to the inability of reduced operating room and recovery room expenses to offset the greater cost associated with employing an allograft for ACLR[14].

Barrera *et al*.[15] compared the costs associated with ACLR in 160 patients employing either BPTB autograft (n = 106) or BPTB allograft (n = 54) performed at an ambulatory surgery center. The study measured a total mean cost (including supply cost, case time per minute, personnel, and facility cost) of $3154 ± 704 for an autograft versus $4147 ± 943 for an allograft. Based on supply costs, which made up 69% of the total costs for the allograft group and 57% for the autograft group, it was determined that ACLR performed using allograft was the most expensive alternative. Moreover, the price of allograft tissue could also increase due to various treatment, storage, and sterilization methods[15].

Further, one of the economic studies compared the soft-tissue allografts (n = 46) and autografts (n = 50) undergoing arthroscopic ACLR during 12 months concerning direct expenses, reimbursement rates, gross contribution margins, OR and RR time in ACLR. The average direct cost and operating room (OR) time at the facility for allografts were $4587 and 92 minutes, respectively, whereas these figures were $3849 and 125 minutes for autografts. Due to the lengthier surgical times involved in autograft cases, the contribution of OR expenditures for autograft procedures was $556 higher than for allograft procedures. Allograft cases had supply costs that were $1392 more than autograft cases, primarily because allograft material is more expensive. The cost of the allograft was covered by reimbursement in an outpatient environment, offsetting its increased cost [16].

Cost Components of ACLR

The cost components involved in ACLR are driven by several factors. These primary factors can be broadly divided into patient-specific and surgeon-dependent (Table 2). In the current healthcare environment, it is customary for patients who need elective surgery to ask about the potential cost drivers for their operation. As the healthcare industry gets progressively competitive and individual gains more power as consumers, the cost variability affects the choice of graft in primary ACLR. In a prior study, it was discovered that patients with high body mass index (BMI) and pre-existing comorbidities had higher outpatient rotator cuff replacement costs. These patient-driven factors could make the technical or anaesthesia parts of the treatment more difficult, increasing the time spent in the OR and the overall cost of the procedure [18]. However, the physicians have no control over the patient-specific cost factors, but surgeons have some control over the surgical procedure, which can affect the overall cost of ACLR. For instance, one study showed a nearly 12-fold difference in costs among surgeons in a single practice setting [19]. Moreover, facility fees may also vary depending on the location of the performed ACLR procedure. In this context, ambulatory centres, for example, have been shown to decrease ACLR costs by as much as $1371 to $7390 [20].

Table 2: Primary factors contributing to the overall cost of ACLR

S.no	Patient-specific factors	Surgeon-dependent factors
1.	Sex	Type of medical center/hospital setting
2.	Age	Surgeon’s fees
3.	Ethnic/race	Type of Anesthesia
4.	Activity level	OR time spent
5.	Chronic medical condition (if any)	Hospitalization stays
6.	Primary Insurance	Imaging/diagnostic test
7.	Annual income	Availability of graft
8.	Patient preference for graft	
9.	Ancillary cost	

Hospitalization stays: In recent decades, there has been a significant and concerning rise in healthcare expenses, exhibiting an exponential growth pattern that is widely acknowledged as unsustainable. One-third of healthcare expenditures are allocated to surgical care. The process of estimating, reviewing, and comprehending the expenses associated with surgical procedures is a crucial undertaking in the realm of cost management and reduction. ACLR is a multifaceted orthopaedic intervention aimed at the replacement of a torn or impaired anterior cruciate ligament within the knee joint. The standard protocol generally necessitates a period of hospitalization to ensure appropriate post-operative care and facilitate the patient's recuperation. One of the epidemiological studies conducted on the Brazilian population undergoing ACLR cases in the public hospital system between January 2008 and December 2014 demonstrated that the average length of stay over the 7 years was 2 ± 0.23 days of hospitalization. In 2008, the average was 2.4 days but it reduced to 1.8 days by 2014. The total cost for the whole period, after adjusting for inflation, was US$56 million with a mean of US$1,145 per ACLR. From 2008 to 2014, the total cost increased by 115% (from US$5 million in 2008 to 11 million in 2014) while the total cost per surgery increased by 31% (from US$1,067 in 2008 to US$1,396 in 2014) [21].

It is imperative to acknowledge that the expense associated with hospitalization exhibits significant variation, contingent upon elements such as the geographical location of the medical facility, the extent of care administered, the duration of the stay, and the presence of any complications. Patients should engage in discussions with their healthcare providers and insurance companies to have a more comprehensive comprehension of the potential financial implications associated with ACLR surgery and the subsequent hospitalization period.

2. Operation room: The operational costs associated with ACLR surgery are a significant component of the overall cost of the procedure. It is crucial to bear in mind that the

precise allocation of operating expenses may differ depending on variables such as the geographical location of the hospital, the fees charged by the surgeon, the type of graft material employed, and the intricacy of the surgical procedure. Participation of pateints in discussions with their healthcare providers and insurance companies to gain a comprehensive understanding of the potential operating expenses that may be incurred as a result of undergoing ACLR surgery.

Considering that surgical care constitutes approximately 30% of total health care expenditure in the United States, it is imperative to establish a data-based benchmark for OR costs and delineates the factors that contribute to these expenses. The OR, being the second most costly component of surgical treatment, necessitates a comprehensive understanding of its cost structure. Raft *et al*. [22] discuss the matter of allocating variable costs, as well as fixed costs, and distinguishing between direct and indirect costs. In the context of OR expenses, direct costs encompass various components, including labor expenditures for medical professionals, such as doctors, nurses, and other staff members directly involved in the operating room. Additionally, direct costs encompass expenses related to medications, medical devices, implants, depreciation, the cost of specialized equipment, and the services of external laboratories.

Physician recommendations: The pivotal role of a physician in the recommendation of an intervention is a fundamental component of patient care and the broader healthcare system. Physicians fulfill multiple essential functions in the context of providing recommendations for interventions, encompassing medical treatments, surgical operations, lifestyle modifications, and various therapeutic strategies. A retrospective analysis was conducted on a cohort of 1,038 patients who underwent ACL reconstruction across a span of five years. A surgical procedure was conducted by a total of five distinct surgeons. A survey was sent to individuals who had been under observation for a minimum duration of 24 months in order to determine the precise category of graft employed the reasoning behind their choice of that particular graft, and their degree of contentment with both the graft and the subsequent results. Upon the completion of the study, it was determined that the predominant factor influencing the selection of grafts was the suggestion provided by physicians, accounting for 74.2% of cases. Furthermore, it is worth noting that out of the entire patient population, a significant majority of 93% expressed satisfaction with the choice of transplant. It is noteworthy that a majority of the patients, specifically 63%, exhibited a preference for utilizing allograft materials in the context of ACLR [23].

Hospital setting: The location of the procedure is the final significant factor under the surgeon's control; in this case, there was no cost difference between surgeries performed at privately owned facilities and those performed at facilities operated by hospitals as described by Bokshan *et al*. [24] Moreover, there was an increase in the number of ACLRs being conducted in outpatient ambulatory surgery centers in comparison to hospital settings between the years 1994 and 2006 [25]. The proportion of ACLRs performed at freestanding surgery centers increased from 13.8% in 1994 to 53.4% in 2006. Consistent with the research conducted by Hollenbeck *et al*. [26] our analysis revealed that ambulatory surgery centers demonstrated comparable performance to hospital-owned centers, without incurring any additional cost. Legislators and regulators must acknowledge the increasing body of research that demonstrates either the non-inferiority or superiority of privately run surgery centers in comparison to hospital-owned centers.

Anaesthesia: The effective use of anaesthesia is of paramount importance in the context of ACLR surgery. The implementation of this practice guarantees the provision of optimal comfort and safety for the patient throughout the surgery, facilitates the surgical team's efficiency, and mitigates post-operative pain and suffering. General anaesthesia ensures Inducing a state of unconsciousness in the patient effectively renders them devoid of awareness and pain sensations throughout the surgical procedure while regional anaesthesia includes epidural anaesthesia or spinal anaesthesia to induce localized numbness in certain areas of the body. For the management of ACLR, it is common practice to administer a localized anaesthetic, such as a femoral nerve block, to effectively alleviate pain both during and in the early postoperative period. One of the studies carried out by Bokshan *et al*.[24] predicted that the primary factor that significantly impacted the expenses associated with ACLR was just the utilization of general anaesthesia. According to their study, significant cost increases of $5,783, $2,873, and $1,780 were observed concerning the existence of a meniscal repair, preoperative nerve block, and general anaesthesia, respectively [24].

It is imperative to acknowledge that the selection of anaesthesia for ACLR is contingent upon several aspects, encompassing the patient's medical background, the surgeon's inclination, and the particular surgical methodology employed. A comprehensive discussion between patients and their surgical team before the treatment, wherein they can deliberate upon anaesthesia alternatives and express any apprehensions or queries. This proactive approach enables patients to acquire the necessary knowledge and understanding, empowering them to make well-informed decisions about their healthcare.

Value added consideration

Quality-adjusted life years (QALYs)

Health outcomes are typically evaluated via the use of a metric that tries to simultaneously capture improvements in the length and quality of life because it is difficult to compare extremely different outcomes (e.g., premature deaths prevented vs. headaches prevented). The projected lifespan of the affected persons and its quality are combined to create this unit, the QALY. It is theoretically conceivable to evaluate the costs of the procedure of producing various health outcomes by evaluating all health benefits in terms of QALYs. Over the last two decades, QALYs have become increasingly widely used as a measure of health outcomes. One of the benefit of QALYs is that they make it possible to compare the effectiveness and cost-effectiveness (or cost-utility) of therapies used in very distinct disease areas, even though their different outcomes would prevent them from being comparable within a CEA.[10] In context of primary ACLR, there are paucity of evidences which reflect the direct consequence on QALY due to preferred graft choice.

Genuario and colleagues conducted a cost-effectiveness analysis employing a simplified decision tree model to

assess the cost-effectiveness of the three most popular ACL reconstructive graft tissues: BPTB, quadruple HS autograft, and allograft. The authors only took into account the direct expenses of the operation and any additional direct postoperative rehabilitation costs or indirect societal or patient costs. The base model demonstrated that, at an average cost of $5373, HS autograft was both the least expensive and the most efficient graft, providing 0.912 QALY. With an effectiveness of 0.966 QALY, the BPTB was $207/case more expensive than HS on average while allografts were the least efficient (0.904 QALY) and most expensive ($1585/case additional to HS). According to this model, it is proposed that utilizing a hamstring autograft for ACLR surgery is the most economically efficient approach for the typical patient with an ACL deficit. Nevertheless, certain clinical circumstances that alter the postoperative probability of various problems may influence surgeons in their decision to use either allografts or BPTB grafts. The purpose of cost-effectiveness analysis is not to supplant the judgment of individual clinicians but rather to evaluate the effectiveness and costs associated with hypothetical groups involved in particular complex decision-making processes [27].

Another systematic review carried out by Filbay *et al*. [28] comprised 14 included studies that reported health-related quality of life (HRQoL) outcomes for a total of 2493 participants at a mean of 9 years (range, 5-16 years) after ACLR. The study revealed that graft type, sex, age at surgery, and time from injury to surgery were not associated with HRQoL outcomes. The presence of surgeries, meniscal injuries, and significant radiographic osteoarthritis is correlated with poorer health-related quality of life outcomes following ACLR. Nevertheless, it is imperative to exercise prudence when interpreting these correlations, given that they were solely examined in a limited number of research. However, reviewing HRQoL outcomes after these surgeries would be an interesting area for future research and warrant further study [28].

Patient-centered outcomes

Utilizing verified patient-reported outcome measures (PROMs) and gathering information from patient interviews, surveys, and questionnaires are methods used in ACLR to evaluate patient-centered outcomes. The objective is to document the patient's perception of their ACLR-related healing, contentment, and general well-being. Healthcare professionals can better understand the effects of ACLR on patients' lives and modify treatment plans to improve their outcomes and general satisfaction by putting a strong emphasis on patient-centered outcomes. Patient-reported outcome measures (PROMs), such as the Lysholm scale, the 12-item Short Form Health Survey (SF-12), and the International Knee Documentation Committee (IKDC) Subjective Knee Evaluation, are frequently used as benchmarks to gauge postoperative improvement [29]. Patients can easily complete these questionnaires before surgery, and they can be longitudinally monitored at predetermined intervals after surgery. Cost-effectiveness evaluations can consider the patient's viewpoint and the effects of ACLR in real-world settings by including PROMs. It enables a more thorough assessment of the economic value of the intervention, taking into account not just the direct expenses but also the advantages and results that are most significant to the patients themselves.

Conclusion

In conclusion, it can be construed that cost-effectiveness plays a pivotal role in determining the efficiency of ACLR in the long run. Although there is a paucity of findings, still considering the cost-effectiveness analysis in graft selection, autograft has more promising outcomes as compared to allograft in every aspect. However, the overall cost of autograft ACLR is based on several other variables that equally participate in computing the final cost of the surgery. Therefore, the influence of those factors cannot be overruled. Moreover, incorporating value-added elements into CEA necessitates adopting a comprehensive and all-encompassing strategy for evaluating the effects of healthcare interventions. This approach acknowledges the need to consider not only cost-effectiveness but also the complex aspects of healthcare delivery and its broader implications for persons and society.

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