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Relationship of knee function and graft type to ankle function and dynamic balance after anterior cruciate ligament reconstruction

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ABSTRACT

Background: Anterior cruciate ligament (ACL) injury is one of the most common cases experienced by young indiindividual, uscially those who are active in sports. ACL injuries can be treated with reconstruction. Anterior cruciate ligament reconstruction (ACLR) is the most effective and common orthopedic technique given to ACL patients. ACLR will cause the patient to experience decreased knee and ankle function and impaired dynamic balance.

Objective: To determine whether there was a relationship between knee function and graft type on ankle function and dynamic balance after ACLR.

Methods: The research used a literature review method that extracting data from five scientific articles related to knee function and graft type to ankle function and dynamic balance after ACLR. Literature searches were conducted online through PubMed and Google Scholar using the keywords "ACL injury", "anterior cruciate ligament reconstruction", "knee function", "ankle function", "graft type", and "dynamic balance".

Results: Based on the results of the journal review, it was found that after ACL reconstruction, knee function, and graft type selection would affect ankle function and dynamic balance. Decreased knee function leads to disruption of dynamic balance, and the choice of graft type could cause weakness in ankle function.

Conclusion: Based on some of the literature that has been collected along with the previous discussion, that there might be several problems that arise due to ACLR, such as decreased muscle strength, which could affect knee function as well as disruption of dynamic balance and graft type selection which caused weakened ankle function.

Keywords: ACL injury, anterior cruciate ligament reconstruction, ankle function, dynamic balance. graft type, knee function.

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Introduction

The anterior cruciate ligament (ACL) is one of the ligaments in the knee that serves to stabilize the knee joint and has the potential to be injured. ACL injuries are most commonly experienced by young individuals, especially those who are active in sports.[1] Most ACL tears occur in athletes through contact and noncontact mechanisms. These injuries are characterized by ligament rupture at the knee joint. When the injury occurs, it will usually be characterized by sound and followed by pain that is so severe that it interferes with activity.[2,3] A study reported that women have a higher risk of ACL injury.[4,5] The number of ACL injury cases per year is estimated at 200.000 and as many as 100.000 undergo reconstruction.

Anterior cruciate ligament reconstruction (ACLR) is one of the most influential and standard orthopedic techniques provided to ACL patients. ACLR aims to recreate knee stability, prevent complications such as swelling, muscle weakness, and decreased balance, restore knee function, prevent further knee injury and reduce the risk of knee osteoarthritis, and optimize long-term quality of life, as well

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as prevent joint degeneration by taking grafts from the hamstrings, quadriceps, and patella tendons.[6,7] After ACLR, many patients exhibit impaired function characterized by instability, knee pain, limited range of motion, quadriceps strength deficits, decreased functional performance, and neuromuscular dysfunction, which can lead to inferior outcomes and increased risk of re-injury.[8,9] After ACLR, an estimated 82% of individuals return to sports participation, but only 63% return to pre-injury levels of sports participation, and only 44% return to competitive sports.[10]

The choice of graft type also affects the functional condition of the patient. In ACL reconstruction. Patella tendon-bone autograft (BPTB) and hamstring tendon autograft (HT) are the most commonly used autografts for ACLR. Pain, stiffness, and limited ROM when patients perform knee flexion and extension movements are the effects caused after patients undergo ACLR.[3,11] After ACLR, there is also impaired muscle function, such as decreased quadriceps and hamstring strength, which leads to decreased knee function, as well as dynamic balance.[12] A study compared the functional results of reconstruction patients using HT graft type and peroneal tendon (PT) autograft. The results of the study showed that the use of HT caused decreased knee function, and the use of PT graft type caused decreased ankle strength, especially during plantar flexion-ankle.[9,13]

Based on the above background, this study was conducted to find out more about the relationship between knee function and graph type to ankle function and dynamic balance in patients after undergoing ACLR. In addition, this research is also essential to find out the patient's condition after undergoing surgery and how long the recovery process takes. This research is essential because there are still limited studies that specifically discuss the relationship between knee function and graft type to ankle function and dynamic balance in patients after ACLR surgery. Researchers hope that this research in the future can provide benefits for physiotherapist students and other readers to add insight and find out the physical condition of patients after ACLR surgery.

Methods

The research method used a literature review study using secondary data in the form of research journals obtained from various scientific journal databases on the internet relating to knee function and graft type to ankle function and dynamic balance after ACLR. Literature articles were obtained through searches on PubMed and Google Scholar using the keywords of "ACL injury", "anterior cruciate ligament reconstruction", "knee function", "ankle function", "graft type", and "dynamic balance". The literature was selected based on inclusion and exclusion criteria. The inclusion criteria used in this literature review were 1) Literature was published from a credible institution; 2) The literature was published at least from the last 10 years; 3) Contains two or more variables such as ACL reconstruction, knee function, ankle function, dynamic balance, and graft type. The exclusion criteria of this study washe sample included had bilateral ACLR and multiple injuries, including fracture and joint dislocation. The literature used in the literature review had met the criteria set by the author.

Results

From the results of the literature that the author has found, 5 journals are relevant to the title of this research, which have been included in **Table 1**.

In the study of Rongjin Chen et al. showed some significant findings, this study was conducted on 50 patients who underwent ACLR using autologous tendons to investigate the correlation between graft maturity and knee function after ACLR. Secondly, knee joint function was evaluated using IKDC, analysis was performed at 6 months and 2 years after surgery, and it was found that IKDC scores at 6 months and 2 years after surgery were significantly higher than before surgery (pre-op, 43.9±3.2; post-op, 60.2±4.0; two years post-op, 77.6±6.2. p=0.000), and all scores at 2 years after surgery were also significantly higher than at 6 months ($p<0.05$). Third, anterior cruciate ligament reconstruction with hamstring tendon autograft may affect graft maturity. Fourth, postoperative rehabilitation of the anterior cruciate ligament in adolescents can improve quadriceps muscle strength and gradually improve knee joint motion.[24]

In the study of VanZile, A., et al. showed no group-by-limb body interaction effect for anterior [$F(2, 31) = 0.26$; $p = 0.77$], posteromedial [$F(2, 31) = 0.86$; $p = 0.43$], or posterolateral [$F(2, 31) = 0.41$; $p = 0.67$] Y Balance Test distance traveled, or single hop test [$F(2, 31) = 0.04$; $p = 0.96$] or triple hop test distance [$F(2, 31) = 0.03$; $p = 0.97$], indicating that the groups showed similar degrees of inter-limb asymmetry in dynamic balance and hop test performance. However, there was a main effect of limb on Y- Balance Test distance for anterior [$F(1, 31) = 16.52$; $p < 0.001$] and posteromedial [$F(1, 31) = 9.76$; $p = 0.004$], as well as single hop test [$F (1, 31) = 15.55$; $p < 0.001$] and triple hop test [F (1, 31) = 20,92; p <0,001]. The results showed that the group of athletes who underwent ACLR had deficits in dynamic balance and hop performance for the injured limb, compared to the uninjured limb, and the magnitude of inter-limb asymmetry in dynamic balance and hop performance after ACLR was independent of meniscus injury history.[19]

In the study of Nizamettin, Guzel, et al. aimed to compare the postoperative results of the modified all-inside ACLR technique for 6 months. Patients were given the Y-Balance test to compare anterior, posterolateral, meniscus, and composite scores for 232 operated and healthy legs. The results showed that the operated leg had a lower score than the healthy leg, and there was no significant difference ($p>0.05$). In the single-leg hop tests (SLHT), significant differences were found in all tests, with the healthy leg scoring slightly higher than the operated leg. In a study evaluating balance and lower limb function after ACLR with different graft types (PT, HT, and allograft), it was reported

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Table 1.

Author	Title	Methods	Results
Rongjin Chen et al. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. (2021)	Correlation between graft maturity and knee function after anterior cruciate ligament reconstruction	Study design: *cohort* Sample size: 50 patients Independent variable: knee function after ACL reconstruction Dependent variable IKDC score at 6 months and 2 years after surgery Statistical test: IKDC	Comparison of knee function scores between pre and *post-op* (n=50): IKDC: pre-op, 43.9±3.2; *post-op*, 60.2±4.0; *two years post-op*, 77.6±6.2. *p=0.000*
Adam VanZile, Malcolm Driessen, Patrick Grabowski, Hanni Cowley, Thomas Almonroeder (2022)	Deficits in Dynamic Balance and Hop Performance Following ACL Reconstruction Are Not Dependent on Meniscal Injury History	Study design: *Cross-sectional*. Sample size: 34 athletes Dependent variable: *dynamic balance* and *hop performance* measured by YBT and SLHT Independent variables: absence of a history of concomitant meniscus injury and type of surgical intervention Statistical test: YBT and SLHT	YBT; anterior [F(2, 31) = 0.26; p = 0.05]. 0.77], posteromedial [F(2, 31) = 0.86; p = 0.43], or posterolateral [F(2, 31) = 0.41; p = 0.67]. SLHT: [F(2, 31) = 0.04; p = 0.96] or *triple hop test distances* [F(2, 31) = 0.03; p = 0.97].
Nizamettin Güzel, Ahmet Serhat Genc, Ali Karim Yılmaz, and Lokman Kehribar (2023)	The Relationship between Lower Extremity Functional Performance and Balance after Anterior Cruciate Ligament Reconstruction: Results of Patients Treated with the Modified All-Inside Technique	Study design: *Retrospective cohort* Total sample: 22 athletes Independent variable: *Lower Extremity Functional* Dependent variable: knee function outcome score and YBT reach distance. Statistical test: YBT and SLHT	YBT *reaches distances of the operated (ACL-Leg) and healthy leg (*ANT*,* PL*, and* PM*).* ANT: ACL *Leg*, 72.54; *Healthy Leg,* 74.68; p-value = 0.123 PL: ACL Leg, 67.98; *Healthy Leg*, 74.57 p-value= 0.592. PM: ACL Leg, 79.88; Healthy Leg, 82.16; p-value= 0.884 SLHT SH: ACL Leg vs Healthy Leg, 114.14 ± 25.14 vs. 103.36 ± 29.21; p = 0.006) TH: ACL Leg vs. Healthy Leg, (392.05 ± 87.92 vs. 362.73 ± 88.78; p= 0.007) CH: ACL Leg vs Healthy Leg, (340.59 ± 89.12 vs. 319.14 ± 75.53;p= 0.038).

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The MARS Group (2014)	Effect of graft choice on the outcome of revision anterior cruciate ligament reconstruction in the Multicenter ACL Revision Study (MARS) Cohort	Study design: *Prospective cohort study* Sample size: 1205 patients Independent variables: patient demographics such as age, gender, *body mass index,* smoking status, and education level, Dependent variables: graft failure, reoperation, and patient-reported outcome measures including IKDC Statistical test: IKDC	*Baseline and 2-year post-op* IKDC *score* IKDC: *Baseline,* 52 (38,63); *2 year post-op*, 77 (61.86).
C. Vijay, M.S. Santosh, Chandra Avinash and T. Adarsh, (2022)	Is Peroneus longus autograft a better alternative to the Hamstring autograft for anterior cruciate ligament reconstruction? - A randomized control study	Study design: *A prospective randomized study* Sample size: 45 Independent variable: ankle *outcome* measured by AOFAS *score* Dependent variable: type of *autograft* used for ACLR Statistical test: AOFAS	AOFAS Peroneus Longus: pre-op, 100 ± 0.00; 6 *months* - 90.48 ± 2.37; 1 *year* - 96.43 ±3.13

IKDC, international knee documentation committee, YBT, y-balance test, SLHT, single leg hop tests, SH, single hop for distance, TH, triple hop for distance, CH, crossover triple hop for distance AOFAS, American Orthopedics Foot and Ankle Scoring

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that the ACLR group had decreased anterior reach distance in balance on both sides.[26]

In a study conducted by the multicenter ACL revision study group (MARS Group) showed that the current tibia tunnel hole position and current femoral fixation influenced the outcome of ACL surgery. There were 4 current tibia tunnel hole positions and 4 types of current femoral fixation that affected surgical outcomes. The results of this study also showed that patients who underwent ACLR using allograft had a higher risk of failure compared to patients who used autograft. However, there was no significant difference in surgical outcomes between patients using allograft and autograft at 2 years after surgery. In addition, the results also showed that patients undergoing ACL surgery had a significant improvement in the IKDC score at 2 years after surgery compared to their baseline score before surgery (Baseline, 52 (38.63); 2 years post-op, 77 (61.86)).[25]

The study of C. Vijay et al. showed that there was a decrease in the American Orthopedics Foot and Ankle Scoring (AOFAS) score on ankle functional results at a 6-month follow-up in the patient group using peroneal tendons and at 1-year follow-up showed improved results after ACLR (pre-op, 100 ± 0.00; 6 months - 90.48 ± 2.37; 1 year - 96.43 ± 3.13). These results are supported by several studies listed in this journal which state that there is a minimal decrease in AOFAS scores in the group of patients using the peroneal tendon compared to the hamstring group.[9]

Discussions

Graft type is one of the factors that affect functional lower limb motion in ACLR patients. ACLR can be performed with autograft or allograft. Mistary's research, Hema et al. stated that ACLR with autograft has better results than with allograft, and in terms of cost, autograft is more economical, so it is the first choice in surgery.[14] Reconstruction with autograft is an operation by taking tendons from the ipsilateral side of the patient himself, the most commonly used tendons are BPTB taken from the ipsilateral third of the patellar tendon and HT tendon grafts taken from the semitendinosus and gracilis tendons, besides that some orthopedic surgeons try to use the peroneus longus tendon as an option and have shown good functional results.[15,16] The use of BTPB autografts can cause anterior knee pain due to the incision at the time of retrieval and the possibility of decreased extensor strength, while the use of HT autografts is associated with prolonged knee flexion weakness.[14,17,18]

Knee function weakness is a common condition after ACL and ACLR injuries. After ACLR patients will experience short-term complications such as infection and deficits in knee movement and strength, while long-term complications are reduced ability to return to activities.[14] After ACLR there is impaired muscle function such as quadricep decline which is one of the intrinsic factors shown to affect knee joint function.[16] Quadricep weakness develops rapidly after injury and ACLR a study reported quadriceps strength deficits from 2% to 20% in subjects who had more than 2 years of ACL surgery. In addition, there is also a decrease in hamstring muscle function which can cause knee flexion limitations resulting in functional limitations, especially when patients perform daily activities.[20] Another study also reported that hamstring strength deficits were found in the HT group during knee extension.[21] This occurs due to the retrieval of quadriceps and hamstring tendons, causing functional limitations in the movement of post-ACLR patients.

Dynamic balance post ACLR surgery is affected by poor knee function caused by decreased quadriceps muscle strength. The y-balance test is commonly used to assess lower extremity dynamic balance. VanZile, Adam, et al. conducted a dynamic balance analysis using the y-balance test and hop test, which showed that the uninjured limb had greater dynamic stability for maximal anterior and posterolateral reach. In contrast, the reconstructed limb had deficits in balance and hop performance even after completing postoperative rehabilitation.[19,22] In addition, the ACL injury group showed reduced performance in both tests. ACL injuries cause knee instability with functional deficits and damage to other joint structures, such as the meniscus. A study conducted by Akbari, Asghar, et al. provided results that dynamic balance after ACLR surgery can be improved with balance training.[23]

The choice of graft type in ACLR also affects the ankle strength of the patient. Vijay, C. et al., conducted a study comparing the use of HT and PT. The study was conducted on 45 patients who underwent ACLR,[9] patients were included in the HT group and 23 patients in the PT group. this study showed an increase in knee flexion strength that was better in the PT group compared to the HT group. However, the use of PT showed ankle weakness, namely ankle plantarflexion and eversion strength reduced at 6 months after reconstruction, and at 1 year of recovery, the condition began to improve but did not reach normal conditions.[9]

Conclusion

Based on some of the literature that has been collected along with the previous discussion, the results indicated that there might be several problems that arise due to ACLR, such as decreased muscle strength, a poorknee function, and disruption of dynamic balance. The choice of graft type greatly affects knee function, dynamic balance in patients who choose to use hamstring tendon autografts, and decreased ankle function that occurs due to the use of peroneal tendon autografts.

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Conflict of interest

This research is devoid of any conflicts of interest

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Author contributions

NNR conducted a literature search, conceptualized the research design, and prepared and edited the paper; GV and IK also conducted a literature search and reviewed the paper.

Ethical consideration

This review study used published articles that are accessible. Thus, this study did not require any informed consent or ethical consideration.

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