What is the Optimal Graft for Primary Anterior Cruciate Ligament Reconstruction Surgery?

A Systematic Literature Review and Bayesian Network Meta-Analysis

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PROTOCOL

Review title and basic details	
Review title	What is the Optimal Graft for Primary Anterior Cruciate Ligament Reconstruction Surgery? Systematic Literature Review and Bayesian Network Meta-Analysis.
Condition or domain being studied	Subjective patient satisfaction, objective knee stability, and rates of graft failure after primary ACLR surgery in adult patients using all available literature to find the optimal graft choice.
Rationale for the review	
Original language title	English
Review objectives	We performed this network meta-analysis to comprehensively compare the clinical outcomes and adverse events of the four main autografts following ACL reconstruction.
Keywords	
Search	
Searches	PubMed/MEDLINE, Embase, Web of Science Core Collection, Scopus, Cochrane
Study design	High-quality Randomized controlled trials (RCTs)
Eligibility criteria	
Population	Adult patients who underwent primary ACL reconstruction surgery following traumatic ACL injury.
Intervention(s) or exposure(s)	Studies meeting the following inclusion criteria will be considered: 1. Adult patients (studies with mean age of at least 18 years) who underwent primary ACLR 2. Randomized controlled trial (RCT) study design (studies with Level of Evidence I or defensible Level of Evidence II - must be ***randomized*** RCTs that were designated with Level of Evidence II) 3. Reported subjective and/or objective clinical outcomes or adverse events Exclusion criteria: 1. Revision ACLR 2. Pediatric population (< 18 years old) 2. Animal studies, in-vitro biomechanical studies, cadaver studies, case-control studies, reviews, systematic reviews and meta-analyses, conference abstracts, letters, and those without original study data
Comparator(s) or control(s)	ACLR using the following autografts: 1. Quadriceps tendon 2. Peroneus longus tendon 3. Hamstring tendon 4. Bone-patellar tendon-bone 5. Achilles tendon 6. Tibialis anterior
Outcomes to be analyzed	
Main outcomes	IKDC Subjective Knee Form, Instrumental Laxity, Graft Rupture
Additional outcomes	Lysholm, Tegner, Pivot Shift, Lachman, Clinical Failure, Revision Rates
Data collection process	
Data extraction (selection and coding)	Two independent authors will perform data collection. Descriptive data on the study level will be recorded: author, publication year, number of subjects, mean age, number of male and female subjects, mean follow-up duration, study design, and outcome data.
Risk of bias (quality) assessment	Cochrane Risk of Bias Assessment (RoB2) will be used for assess methodological quality and to evaluate risk of bias of the studies included in the review.
Planned data synthesis	
Strategy for data synthesis	A network meta-analysis of pooled effect size estimates from RCTs will be primary analysis and those from all study designs (observational and case studies) in addition to RCTs will be part of sensitivity analysis to validate the results of the former with the latter.
Analysis of subgroups or subsets	Subgroup analysis will naturally be performed during network meta-analysis by synthesizing and comparing the outcomes of direct and indirect comparisons between six graft types. Meta-regression analysis will be performed using follow up duration, gender, and age as mixed, categorical, and continuous covariate predictors, respectively.
Review affiliation, funding and peer review	
Review team members	Dong Woon Kim MD Janek Surma MD Shayden Bernas Marcin Mostowy MD, PhD Konrad Malinowski MD, PhD
Review affiliation	Johns Hopkins University
Funding source	N/A
Named contact	Dong Woon Kim (d.kim@student.uj.edu.pl)
Timeline of the review	
Review timeline	2026-02-09 to 2026-02-28
Date of first submission to PROSPERO	2025-10-12
Date of registration in PROSPERO	2025-10-12
Current review stage	
Publication of review results	Review results will be published for public access after acceptance for publication.
Stage of the review at this submission	**Review stage** **Started** **Completed** Pilot work ☒ ☒

	Formal searching/study identification	☒	☒
	Screening search results against inclusion criteria	☒	☐
	Data extraction or receipt of IP	☐	☐
	Risk of bias/quality assessment	☐	☐
	Data synthesis	☐	☐
Review status			
Additional information			
Review conflict of interest	None.		
Country	Poland		

https://www.crd.york.ac.uk/PROSPERO/view/CRD42024592549

SYSTEMATIC LITERATURE REVIEW

SEARCH STRATEGY

Started: 2026-02-09
Completed: 2026-02-11

GRAFT TYPE	PUBMED/MEDLINE	EMBASE	WEB OF SCIENCE	SCOPUS	COCHRANE
Patellar tendon	("bone-patellar tendon-bone"[tiab] OR "patellar tendon*"[tiab] OR BPTB[tiab])	('bone-patellar tendon-bone':ti,ab OR 'patellar tendon*':ti,ab OR BPTB:ti,ab)	("bone-patellar tendon-bone" OR "patellar tendon*" OR BPTB)	(TITLE-ABS("bone-patellar tendon-bone") OR TITLE-ABS("patellar tendon*") OR TITLE-ABS(BPTB))	((TI="bone-patellar tendon-bone" OR AB="bone-patellar tendon-bone") OR (TI="patellar tendon*" OR AB="patellar tendon*") OR (TI=BPTB OR AB=BPTB))
Hamstring tendon	("hamstring"[tiab] OR "semitendinosus"[tiab] OR "gracilis"[tiab])	(hamstring:ti,ab OR semitendinosus:ti,ab OR gracilis:ti,ab)	(hamstring OR semitendinosus OR gracilis)	(TITLE-ABS(hamstring) OR TITLE-ABS(semitendinosus) OR TITLE-ABS(gracilis))	((TI=hamstring OR AB=hamstring) OR (TI=semitendinosus OR AB=semitendinosus) OR (TI=gracilis OR AB=gracilis))
Quadriceps tendon[2]	("quadriceps"[tiab] OR "QT"[tiab])	(quadriceps:ti,ab OR QT:ti,ab)	(quadriceps OR QT)	(TITLE-ABS(quadriceps) OR TITLE-ABS(QT))	((TI=”quadriceps OR AB=quadriceps) OR (TI=QT OR AB=QT))
Peroneus longus tendon	("peroneus longus*"[tiab] OR "fibularis longus*"[tiab] OR PLT[tiab])	('peroneus longus*':ti,ab OR 'fibularis longus*':ti,ab OR PLT:ti,ab)	("peroneus longus*" OR "fibularis longus*" OR PLT)	(TITLE-ABS("peroneus longus*") OR TITLE-ABS("fibularis longus*") OR TITLE-ABS(PLT))	((TI="peroneus longus*" OR AB="peroneus longus*") OR (TI="fibularis longus*" OR AB="fibularis longus*") OR (TI=PLT OR AB=PLT))
Achilles tendon	("achilles*"[tiab])	(achilles*:ti,ab OR AT:ti,ab)	(achilles*)	(TITLE-ABS(achilles*))	((TI=achilles* OR AB=achilles*))
Tibialis anterior	("tibialis anterior*"[tiab])	('tibialis anterior*':ti,ab OR TA:ti,ab)	("tibialis anterior*" OR TA)	(TITLE-ABS("tibialis anterior*") OR TITLE-ABS(TA))	((TI="tibialis anterior*" OR AB="tibialis anterior*") OR (TI=TA OR AB=TA))
Randomized Controlled Trials (RCTs)	AND ("anterior cruciate ligament"[Mesh] OR "anterior cruciate ligament*"[tiab] OR ACL[tiab] OR ACLR[tiab]) AND ("IKDC*"[tiab] OR "Lysholm*"[tiab] OR "Tegner*"[tiab] OR "graft failure*"[tiab] OR "graft rupture*"[tiab] OR "instrumental laxity*"[tiab] OR "KT-1000*"[tiab] OR "KT-2000*"[tiab] OR "pivot shift*"[tiab] OR "Lachman*"[tiab]) NOT ("BEAR"[ti] OR "revision"[ti] OR "pediatric"[ti] OR "LET"[ti] OR "allograft"[ti] OR "cadaver*"[ti] OR "biomechanical"[ti]) AND (“Clinical Trial”[pt] OR “Randomized Controlled Trial”[pt]) NOT ("Systematic Review"[pt] OR "Meta-Analysis"[pt] OR "Review"[pt])	AND ('anterior cruciate ligament'/exp OR 'anterior cruciate ligament*':ti,ab OR ACL:ti,ab OR ACLR:ti,ab) AND (IKDC* OR Lysholm* OR Tegner* OR 'graft failure*' OR 'graft rupture*' OR 'instrumental laxity*' OR KT-1000* OR KT-2000* OR 'pivot shift*' OR Lachman*) NOT (BEAR:ti OR revision:ti OR pediatric:ti OR LET:ti OR allograft:ti OR cadaver*:ti OR biomechanical:ti) AND ('Clinical Trial':it OR (Article:it AND 'randomized controlled trial')) NOT ('*Review':it OR 'Systematic Review' OR 'Meta-Analysis')	AND ("anterior cruciate ligament" OR "anterior cruciate ligament*" OR ACL OR ACLR) AND (IKDC* OR Lysholm* OR Tegner* OR "graft failure*" OR "graft rupture*" OR "instrumental laxity*" OR KT-1000* OR KT-2000* OR "pivot shift*" OR Lachman*) NOT (BEAR OR revision OR pediatric OR LET OR allograft OR cadaver* OR biomechanical) AND ("Clinical Trial" OR "Randomized Controlled Trial") NOT ("Systematic Review" OR Meta-Analysis OR Review)	AND (INDEXTERMS("anterior cruciate ligament") OR TITLE-ABS("anterior cruciate ligament*") OR TITLE-ABS(ACL) OR TITLE-ABS(ACLR)) AND (ALL(IKDC*) OR ALL(Lysholm*) OR ALL(Tegner*) OR ALL("graft failure*") OR ALL("graft rupture*") OR ALL("instrumental laxity*") OR ALL(KT-1000*) OR ALL(KT-2000*) OR ALL("pivot shift*") OR ALL(Lachman*)) AND NOT TITLE("BEAR") AND NOT TITLE("revision") AND NOT TITLE("pediatric") AND NOT TITLE("LET") AND NOT TITLE("allograft") AND NOT TITLE("cadaver*") AND NOT TITLE("biomechanical") AND NOT TITLE-ABS-KEY("Review") AND NOT ("Meta-Analysis") AND NOT ("Systematic*") AND (EXCLUDE (DOCTYPE,"re") OR EXCLUDE (DOCTYPE,"ch") OR EXCLUDE (DOCTYPE,"ed") OR EXCLUDE (DOCTYPE,"no") OR EXCLUDE (DOCTYPE,"tb") OR EXCLUDE (DOCTYPE,"le") OR EXCLUDE (DOCTYPE,"er"))	AND (ALL="anterior cruciate ligament" OR (TI="anterior cruciate ligament*" OR AB="anterior cruciate ligament*") OR (TI=ACL OR AB=ACL) OR (TI=ACLR OR AB=ACLR)) AND (ALL=IKDC* OR ALL=Lysholm* OR ALL=Tegner* OR ALL="graft failure*" OR ALL="graft rupture*" OR ALL="instrumental laxity*" OR ALL=KT-1000* OR ALL=KT-2000* OR ALL="pivot shift*" OR ALL=Lachman*) NOT (TI=BEAR OR TI=revision OR TI=pediatric OR TI=LET OR TI=allograft OR TI=cadaver* OR TI=biomechanical) AND (ALL="Clinical Trial" OR ALL="Randomized Controlled Trial") NOT (ALL="Systematic Review" OR ALL=Meta-Analysis OR ALL=Review)

[2] Original search string:
("anterior cruciate ligament reconstruction" OR "anterior cruciate ligament" OR ACL) AND (quadriceps OR "quadriceps tendon" OR QT) AND (autograft OR graft OR autologous)

Literature Search

Table 2 Literature Search Results for Individual Graft Types

	PubMed/MEDLINE	Embase	Web of Science Core Collection
Date	2026-02-09	2026-02-10	2026-02-10
Patellar	156	138	77
Hamstring	269	311	113
Quadriceps	73	109	37
Peroneus longus	2	11	1
Achilles	2	5	0
Tibialis anterior	1	3	0
Records	503	577	227

For later:

Cochrane Reviews
2026-02-11
23
21
10
3
8
13
78

Table 3 Summary of Literature Search Results for All Graft Types Before Deduplication

Database			Date performed
PubMed/MEDLINE	503		2026-02-09
Embase	577		2026-02-10
Web of Science Core Collection Advanced	227		2026-02-10

Records: https://docs.google.com/spreadsheets/d/1ta1ZCbur5G-uSkg0sCTWEw6oVug1BCOlJzlQKQH4eHM/edit?gid=0#gid=0

Deduplication

Started: 2026-02-14
Completed: 2026-02-14

Deduplication was performed using python script a two-tier method based on DOI number and Title for null or blank records. Out of 3,157 records, 1,255 duplicate records were removed, resulting in 1,902 records to be screened.

Step 1 Combine exports from database searches into one *records.csv* file by matching column names.

Source	PubMed	Embase	Web of Science Core Collection
ID (w/o nulls)	PMID	Embase Link PUI	UT (Unique WOS ID) Web of Science Record
DOI	DOI	DOI	DOI
Authors	Authors	Author Names	Authors
Title	Title	Title	Article Title
Year	Publication Year	Publication Year	Publication Year
Journal	Journal/Book	Source	Source Title

Screening

Title and Abstract Screening

Started: 2026-02-15

Completed: 2026-02-20 (150/day)

All randomized controlled trials were included in the title and abstract screening process. All other study designs were not included.

Full-text Screening

Started:
Completed:

All RCT studies were assessed against the eligibility criteria for inclusion.

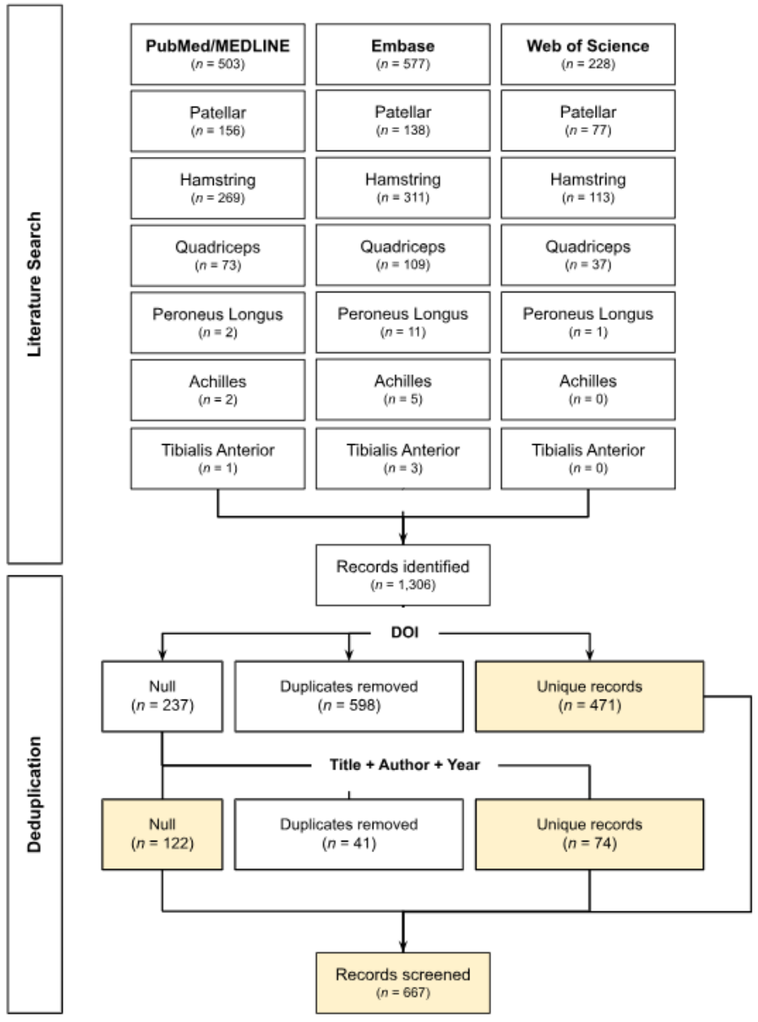
PRISMA Flowchart

1. Database specific results
2. Register specific results
3. Citation results
4. Duplicates records
5. Records screened
6. Records excluded
7. Reports sought for retrieval
8. Reports not retrieved
9. Reports assessed
10. Reports excluded (w/ reasons)
11. Total studies included in review

TABLES

FIGURES

Fig 1 Modified PRISMA Flowchart depicting detailed search and deduplication process.



SCRIPTS

Script 1 Python script for combining literature search results into one file

```
import pandas as pd
import numpy as np

# pubmed
pm_bptb = pd.read_csv('./rct/pubmed/pm_bptb.csv', encoding = 'utf-8')
pm_ht = pd.read_csv('./rct/pubmed/pm_ht.csv', encoding = 'utf-8')
pm_qt = pd.read_csv('./rct/pubmed/pm_qt.csv', encoding = 'utf-8')
pm_plt = pd.read_csv('./rct/pubmed/pm_plt.csv', encoding = 'utf-8')
pubmed = pd.concat([pm_bptb, pm_ht, pm_qt, pm_plt])
pubmed.to_csv('./rct/pubmed/pubmed.csv', encoding = 'utf-8')

# embase
em_bptb = pd.read_csv('./rct/embase/em_bptb.csv')
em_ht = pd.read_csv('./rct/embase/em_ht.csv')
em_qt = pd.read_csv('./rct/embase/em_qt.csv')
em_plt = pd.read_csv('./rct/embase/em_plt.csv')
em_at = pd.read_csv('./rct/embase/em_at.csv')
em_ta = pd.read_csv('./rct/embase/em_ta.csv')
embase = pd.concat([em_bptb, em_ht, em_qt, em_plt, em_at, em_ta])
embase.to_csv('./rct/embase/embase.csv')

# web of science
wos = pd.read_csv('./rct/wos/wos.csv')
wos.head(10)

# scopus
sco_bptb = pd.read_csv('./rct/scopus/sco_bptb.csv')
sco_ht = pd.read_csv('./rct/scopus/sco_ht.csv')
sco_qt = pd.read_csv('./rct/scopus/sco_qt.csv')
sco_plt = pd.read_csv('./rct/scopus/sco_plt.csv')
sco_at = pd.read_csv('./rct/scopus/sco_at.csv')
sco_ta = pd.read_csv('./rct/scopus/sco_ta.csv')
scopus = pd.concat([sco_bptb, sco_ht, sco_qt, sco_plt, sco_at, sco_ta])
scopus.to_csv('./rct/scopus/scopus.csv')
```

Script 2 deduplication.py

```
import pandas as pd
import numpy as np
import mermaid as md
from mermaid.graph import Graph

def deduplicate(df, cols):
    input_file_name = input('Enter file name: ') + '.csv'
    df = pd.read_csv(input_file_name) # A (records)
    cols_input = input('Enter the columns for which to deduplicate based on: ')
    cols = [c.strip() for c in cols_input.split(',')]
    output_file_name = './' + '_'.join(cols) + '_deduplicated.csv'
    prisma_file_name = output_file_name.replace('.csv', '.mmd')

    nulls_mask = df[cols].isnull().any(axis=1)
    df_nulls = df[nulls_mask] # B
    df_non_nulls = df[~nulls_mask] # C

    duplicates_mask = df_non_nulls.duplicated(subset = cols, keep = False)
```

```
    df_non_duplicates = df_non_nulls[~duplicates_mask] # D
    df_duplicates = df_non_nulls[duplicates_mask] # E
    df_kept = df_duplicates.drop_duplicates(subset = cols, keep = 'first')
    df_removed = df_duplicates[~df_duplicates.index.isin(df_kept.index)]
    df_unique = df_non_nulls.drop_duplicates(subset = cols, keep = 'first') # df of unique
    df_deduplicated = pd.concat([df_non_duplicates, df_kept], ignore_index=True) # df of unique + df of non-duplicates

    results = {
        "records": len(df),
        "nulls": len(df_nulls),
        "non_nulls": len(df_non_nulls),
        "non_duplicates": len(df_non_duplicates),
        "duplicates": len(df_duplicates),
        "removed": len(df_removed),
        "kept": len(df_kept),
        "unique": len(df_unique),
        "deduplicated": len(df_deduplicated)
    }

    df_nulls.to_csv(output_file_name.replace('deduplicated','nulls'), index = False)
    df_deduplicated.to_csv(output_file_name, index = False)
    df_removed.to_csv(output_file_name.replace('.csv', '_removed.csv'), index = False)


    return results, df_nulls, df_deduplicated, df_kept, df_removed, output_file_name, prisma_file_name

if __name__ == "__main__":
    results, df_nulls, df_deduplicated, df_kept, df_removed, output_file_name, prisma_file_name = deduplicate(df=None, cols=None)

    graph_text = f"""---
config:
  theme: neutral
  curve: stepBefore
---
graph TD;
A["**records** (*n* = {results['records']})"];
B["null (*n* = {results['nulls']})"];
C["non-null (*n* = {results['non_nulls']})"];
D["non-duplicates (*n* = {results['non_duplicates']})"];
E["duplicates (*n* = {results['duplicates']})"];
F["duplicates kept (*n* = {results['kept']})"];
G["duplicates removed (*n* = {results['removed']})"];
H["unique (*n* = {results['unique']})"];
I["deduplicated (*n* = {results['deduplicated']})"];

A --> B & C;
C --> D & E;
E --> F & G;
D & F --> H"""


    with open(prisma_file_name, "w") as f:
        f.write(graph_text)
```

REFERENCES