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Comparison of long-term outcomes between surgical and conservative management for Anterior Cruciate Ligament Injury

A systematic review

Systematic Review
PEN-12 Seminar "Scientific Research Methods"
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Faculty of Health Sciences Brandenburg
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Abstract

Background: The anterior cruciate ligament (ACL) is a central structure of the knee joint and plays an essential role in the stability and functionality of the joint. Injuries to the anterior cruciate ligament occur frequently, especially in sports, and can lead to long-term consequences such as the development of knee joint osteoarthritis. Despite numerous studies, the optimal treatment method remains unclear, especially regarding long-term treatment outcomes.

Aim: This systematic review aimed to compare long-term outcomes of surgical reconstruction and conservative management in individuals with full-thickness ACL rupture, with a minimum follow-up of ten years.

Methods: A systematic literature search was conducted in PubMed in December 2025. Randomized controlled trials and cohort studies comparing surgical and conservative treatment were included. Outcomes of interest included patient-reported outcome measures (PROMs), radiographic osteoarthritis (ROA), re-injury rates, and secondary surgeries. Data were synthesized descriptively using a narrative approach.

Results: In total, seven articles met the inclusion criteria and were included in the review. Five articles reported on PROMs, three studies reported on ROA, and three studies reported re-injury and subsequent secondary surgery rates. The results from these studies indicate neither surgical nor non-surgical management confer superior PROMs and ROA. Surgical management may confer a protective effect against secondary injuries and surgeries compared to non-surgical management.

Conclusion: At long-term follow-up of at least 10 years, it is inconclusive whether surgical or nonsurgical management of ACL rupture confers superior outcomes.

1 Introduction

The anterior cruciate ligament (ACL) is a central stabilizing structure of the knee and plays an important role in maintaining knee function, limiting anterior tibial translation and internal rotation[1]. Injuries to the ACL afflict mainly sporting populations and commonly occur during deceleration, twisting and cutting movements[2]. Rupture of the ACL can lead to substantial functional limitations and has been associated with further meniscal injuries and an increased risk of knee osteoarthritis[3]. Additionally, clinical consequences such as chronic joint instability, muscle weakness, and reduced levels of physical activity are frequently observed[4]. With an incidence of 68.6 per 100,000 individuals per year, ACL rupture represents one of the most common sports-related injuries[5]. This injury can be managed either surgically or conservatively. Surgical treatment is currently performed predominantly using minimally invasive techniques, whereas conservative management primarily consists of physiotherapy-based interventions. Both treatment approaches aim to restore knee joint stability and to prevent the development of osteoarthritis[6]. At present, there is no clear consensus in the scientific literature as to whether either treatment approach confers a therapeutic advantage. Systematic reviews with follow-up periods of less than ten years provide insufficient evidence to draw a definitive conclusion[7–9]. The aim of this systematic review was to compare the long-term outcomes of surgical and conservative treatment of ACL ruptures, with a particular focus on studies with a follow-up period of more than ten years.

2 Methods

2.1 Eligibility criteria

Studies were selected for inclusion according to predefined eligibility criteria structured around the Population, Intervention, Comparison, Outcomes, and Study design (PICOS) framework.

Population: The review included patients of any age or sex diagnosed with a full-thickness anterior cruciate ligament rupture.

Intervention: Studies investigating primary ACL reconstruction using any graft type were considered.

Comparison: Conservative (non-surgical) management was used as the comparator.

Outcome: Eligible studies reported at least one of the following outcomes with a minimum of ten years' follow-up: patient-reported outcome measures, development of osteoarthritis, re-injury rates, or secondary surgical procedures.

Study design: Randomized controlled trials (RCTs) and cohort study designs.

Exclusion criteria: Studies were excluded if they were not RCTs or cohort studies, involved multi-ligament or revision ACL reconstruction, were not published in English, or were published more than ten years ago.

2.2 Literature search

A systematic search was conducted in PubMed on 20 December 2025 at 4:00 pm. The initial search strategy was developed by the authors (MH, CT) with support from a staff member of the University of Potsdam Rehabilitation Science Faculty (TT). The search term was the following:

("Anterior Cruciate Ligament"[Mesh] OR "anterior cruciate ligament"[Title/Abstract] OR ACL[Title/Abstract]) AND (randomized OR randomised OR cohort OR "prospective cohort" OR "retrospective cohort") AND ((reconstruction[Title/Abstract] OR repair[Title/Abstract] OR operation[Title/Abstract] OR surgery[Title/Abstract] OR operative[Title/Abstract]) AND (non-surgical[Title/Abstract] OR conservative[Title/Abstract] OR nonoperative[Title/Abstract] OR rehabilitation[Title/Abstract] OR physiotherapy[Title/Abstract] OR brace[Title/Abstract])) AND ("long-term"[Title/Abstract] OR "follow-up"[Title/Abstract])

2.3 Study selection

All records identified through the literature search were independently screened by the reviewers. During the initial screening phase, titles and abstracts were assessed for eligibility according to the predefined PICOS criteria. The full texts of potentially relevant studies were retrieved for further review. Reference management and screening were supported using the literature management software Citavi to facilitate handling the identified records. Any disagreements regarding the study inclusion were discussed among the reviewers until consensus was reached.

2.4 Data extraction

Data extraction was performed using Microsoft Excel. Both reviewers independently extracted relevant data from a subset of the included studies, and the extracted information was cross-checked by the other reviewer for completeness and accuracy. The extracted data included author, title, year of publication, study design, sample size, duration of follow-up, mean age, sex and sex distribution of the sample, participant characteristics, details of the intervention and control groups, the graft type used, reported outcomes, main results, as well as the reported limitations and strengths of each study.

2.5 Data synthesis and analysis

A narrative synthesis was performed by outcome type (PROMs, radiographic osteoarthritis, and re-injury/secondary surgeries). Key results were presented in summary tables to highlight patterns and inconsistencies across studies.

3 Results

3.1 Study selection and characteristics

In total, 307 articles were initially identified. The flow chart of the literature selection process, conducted in accordance with the PRISMA guidelines, is illustrated in Figure 1. 295 articles were excluded based on title and abstract screening. An additional five articles were excluded after full-text screening for the following reasons: inclusion of concomitant ligament injuries, mean follow-up of less than 10 years in one intervention group, outcome outside the scope of this review, and absence of statistical comparison between the treatment groups. A total of seven articles were included in the final systematic review[10–16]. Of these, five were cohort studies[10,11,13–15], one was a randomized controlled trial (RCT)[12], and one was a secondary analysis of an RCT[16]. A summary of the study characteristics and results is included in tables 1 and 2.

3.2 Outcome measures

3.2.1 Patient-reported outcome measures (PROMs)

Five articles reported on PROMs. Filbay et al.[16] reported that at 11-year follow-up, conservative management, with ACL continuity at 5-year follow-up, was associated with worse PROMs compared with surgical management ($KOOS_4$ adjusted mean difference, –15.5 [95% CI, –26.4 to –4.7])[16]. This finding is consistent with earlier work by Tsoukas et al.[12], who reported that surgical management is associated with superior PROMs at mean 10-year follow-up (IKDC scores; ACLR group, 86.8 (SD 6.5) versus non-surgical management, 77.5 (SD 13.8), respectively ($p = 0.04$)). In contrast, Urhausen et al.[11], using a larger sample size and comparable follow-up time, found no difference between the groups. The remaining two studies had substantially longer follow-up periods. Van Yperen et al.[10] found no difference between the groups at mean 18 years follow-up, and Kvist et al.[14] found no difference in Quality-of-Life score outcomes at 20- and 35-year follow-up. A summary of the results can be found in tables 3 to 9.

3.2.2 Radiographic osteoarthritis (ROA)

Three studies reported on ROA. Tsoukas et al.[12] found at mean 10-year follow-up, 23.5% of the surgical management group had ROA, and 33.5% in the conservative group. The differences between the groups were statistically insignificant. In a larger sample size with a similar follow-up time, Urhausen et al.[11] also found no significant statistical difference in ROA between the treatment groups (ROA prevalence between groups, surgical management: 10 (12%), conservative management: 2 (8%), $P = 0.37$). These results were replicated at 20-year follow-up by van Yperen et al.[10]. A summary of the results can be found in tables 10 to 11.

3.2.3 Re-injury and secondary surgeries

Three studies reported re-injury and subsequent secondary surgery rates. At mean 18-year follow-up, Hagmeijer et al.[15] reported surgical management had a statistically significantly lower rate of secondary meniscal tears than conservative management ($P < .01$). Melbye et

al.[13] found no difference in major secondary surgeries between the treatment groups. However, the conservative group was more likely to have minor secondary surgery, with meniscal surgery being the most common. These findings are not consistent with those reported by van Yperen et al.[10], who reported no difference in secondary surgeries between the groups. A summary of the results can be found in table 12.

4 Discussion

The findings from our systematic review indicate neither surgical nor non-surgical management confer superior PROMs and ROA. Surgical management may confer a protective effect against secondary injuries and surgeries compared to non-surgical management. These findings are consistent with a previous systematic review by Jia et al.[17] They included studies with a minimum follow-up period of over 12 months and found no difference in PROMs between treatment groups. Notably, the surgical treatment had a lower rate of secondary meniscal surgery (OR 0.37; $p < 0.001$). It is hypothesised that reduced secondary meniscal injury may be a result of improved knee stability with surgical management[18]. Furthermore, our review replicates findings from systematic reviews with shorter follow-up times (≤10 years) that current literature is insufficient to determine whether ACL reconstruction is superior to non-surgical treatment[7–9].

Comparing treatment options remains a challenge in ACL injury research as there is a considerable selection and allocation bias, or confounding by indication, in most studies[19]. In the studies assessing PROMs, three utilised randomisation to determine the treatment groups with optional crossover to surgical management at different time periods[12,14,16]. While this design strengthens causal inference regarding initial treatment effects, crossover to surgery may introduce allocation bias and has low external validity. Furthermore, there is growing awareness of “copers” (ACL-deficient patients who achieve satisfactory knee function with conservative treatment alone) and “non-copers” (individuals who opt for surgery due to unsatisfactory knee function), indicating that successful outcomes may be more dependent on the correct early identification of these subgroups than on the treatment modality itself[20,21]. Two studies allocated treatment based on initial response to conservative management, and one also specified shared decision-making, and subsequently found no difference in PROMs between the treatment groups[10,11]. Additionally, Urhausen et al.[11] reported both patient groups following its treatment algorithm had overall high percentages of satisfaction, similar functional outcomes, and sports participation[11]. This supports further research focusing on identifying success predictors for each treatment strategy.

It was previously hypothesised that ACL reconstruction would provide greater joint stability, reducing the incidence and severity of ROA[22]. Our results align with other systematic reviews that surgical management does not reduce the risk of ROA[19]. ROA is significantly higher in populations with a previous ACL injury[23]. Importantly, radiological

results often poorly correlate with clinical symptoms[24]. In the studies included in this systematic review, only one study differentiated between symptomatic and asymptomatic ROA, limiting the clinical application of these results[11]. Interestingly, in that study only 1 person (<1%) had developed symptomatic ROA.

4.1 Limitations

As aforementioned, all studies in this review had various degrees of selection bias, allocation bias, and confounding by indication. Specifically, reviews with long-term follow-up are particularly susceptible to selection bias due to participant attrition. Additionally, long-term follow-up means the surgical rehabilitation techniques used at the time may be out of date. Therefore, results may not be generalizable to the populations receiving modern treatment methods[10,13–15]. Two studies reported small sample sizes as a methodological limitation[12,16].

5 Conclusion

At long-term follow-up of at least 10 years, it is inconclusive whether surgical or nonsurgical management of ACL rupture confers superior PROMs, and ROA rates are similar. Surgical management appears to confer a protective effect against secondary meniscal surgeries. Further high-quality studies with long-term follow-up are required, particularly those incorporating clinically relevant shared decision-making algorithms and focusing on the identification of predictors of successful outcomes for each treatment strategy, to maximize patient outcomes.

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7 Appendix

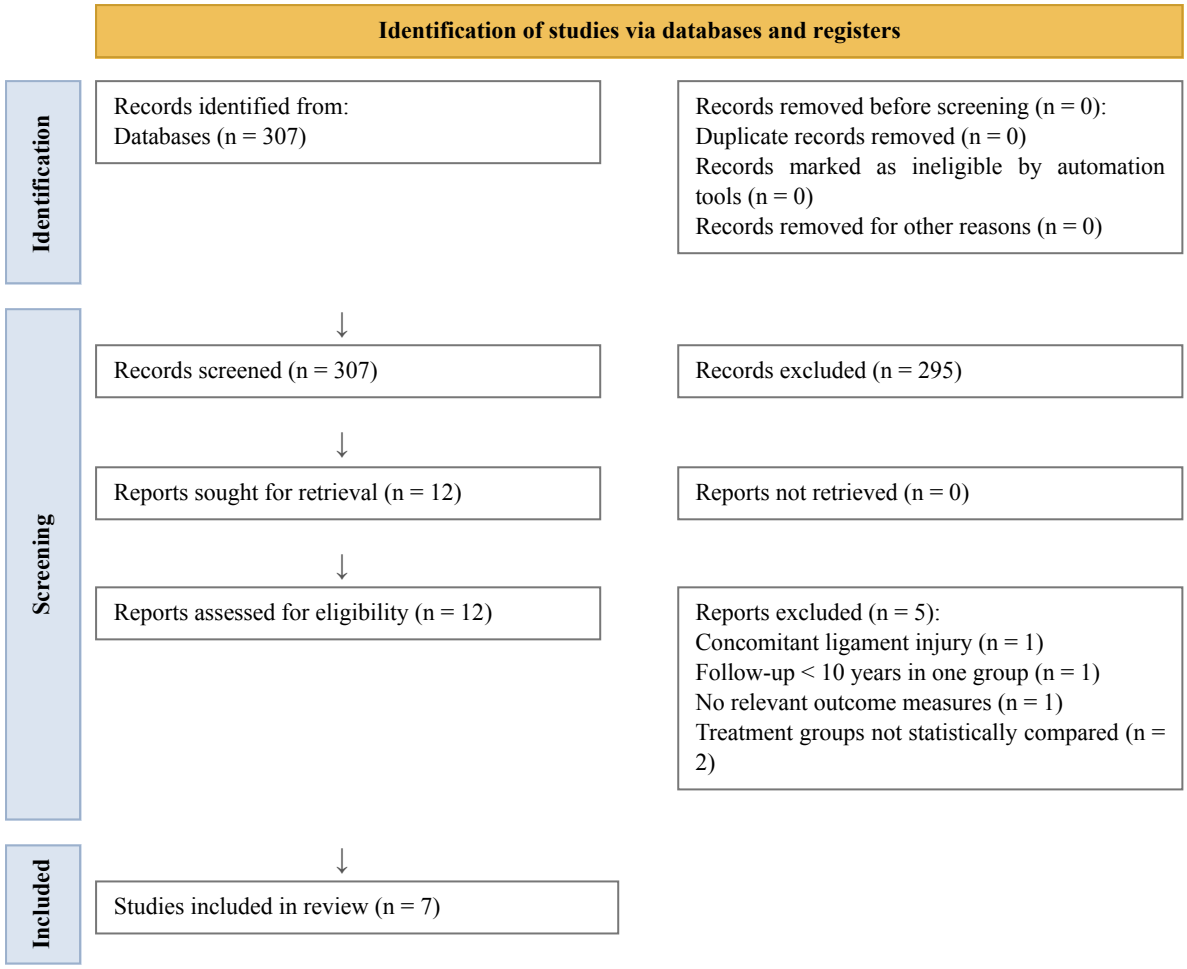

Figure 1. Flow diagram of study selection, prepared in accordance with the PRISMA 2020 statement.

TABLE 1. SUMMARY OF STUDY CHARACTERISTICS

Author	Year	Study design	Follow-up (years)	Total sample	Mean age (±SD)	Female/male (%)
Filbay et al., 2025[16]	2025	Secondary analysis of an RCT	11	105	37 (5)	29/75
Hagmeijer et al., 2019[15]	2019	Cohort	18 (mean)	1,398	28.9 (9.6)	S: 34/66 C: 32.5/67
Kvist et al., 2024[14]	2024	Cohort	20, 35	59	21 (4)	31/69
Melbye et al., 2022[13]	2022	Cohort	20–24 (range)	7,359	S: 25 (NR) NS: 25.5 (NR)	36.7/63.3
Tsoukas et al., 2016[12]	2016	RCT	10.3 (median)	32	S: 31 C: 33	0/100
Urhausen et al., 2025[11]	2025	Cohort	10	191	27.4 (9.8)	48/52
van Yperen et al., 2018[10]	2018	Cohort	20	50	S: 45.8 (6.4) C: 49.8 (6.8)	24/76

S – surgical management; C – conservative management; NR – not reported.

TABLE 2. SUMMARY OF STUDY RESULTS

Study	Relevant outcome measures	Result
Filbay et al., 2025[16]	$KOOS_4$	Non-surgical management with ACL continuity at 5 years is associated with worse patient-reported outcomes compared to surgical management. However, they had less or fewer signs of ROA.
Hagmeijer et al., 2019[15]	Secondary meniscal tears	Delayed ACLR and the non-surgical groups were more likely to have secondary meniscal tears compared to early ACLR.
Kvist et al., 2024[14]	KOOS-QoL, ACL-QoL, European QoL-5 and VAS	No difference found between the two groups.
Melbye et al., 2022[13]	Secondary surgeries	There was no difference between rates of major secondary surgeries between surgical and non-surgical treatment. However, the non-surgical group were more likely to have a minor secondary surgery.
Tsoukas et al., 2016[12]	IKDC, radiographic OA	The surgical group had better reported outcomes but no difference in the prevalence of OA compared to the non-surgical group.
Urhausen et al., 2025[11]	KOOS, IKDC, PASS, ROA	Early ACLR and non-surgical management had similar outcomes. Delayed ACLR has worse outcomes for KOOS sports and QoL.
van Yperen et al., 2018[10]	KOOS, IKDC, secondary surgeries, ROA	No difference in outcomes between the surgical and non-surgical group.

TABLE 3. PATIENT-REPORTED OUTCOME MEASURES — KNEE INJURY AND OSTEOARTHRITIS OUTCOME SCORE, 4 SUBSCALES ($KOOS_4$)

Study	Surgical management	Conservative management with ACL continuity	Between-group comparison (95% CI, p-value)
Filbay et al., 2025[16]	83 (±17)	69 (±29)	–15.5 [95% CI, –26.4 to –4.7]

TABLE 4. PATIENT-REPORTED OUTCOME MEASURES — KNEE INJURY AND OSTEOARTHRITIS OUTCOME SCORE[10,11]

Study	Surgical management		Conservative management		Between-group comparison (95% CI, p-value)
Urhausen et al., 2025[11]	Pain	94.1 (±7.5)	Pain	94.7 (±7.7)	NSS
	Symptoms	88.9 (±11.5)	Symptoms	91.5 (±11.4)	NSS
	ADL	98.3 (±3.9)	ADL	98.3 (±3.8)	NSS
	Sports	87.5 (±15.1)	Sports	89.6 (±14.2)	NSS
	QOL	78.8 (±18.2)	QOL	77.4 (±18.6)	NSS
van Yperen et al., 2018[10]	Pain	91.7 (70.8–100)	Pain	97.2 (80.6–100)	P = 0.487
	Symptoms	85.7 (67.9–96.4)	Symptoms	92.6 (80.4–100)	P = 0.156
	ADL	95.6 (78.7–100)	ADL	98.5 (88.2–100)	P = 0.276
	Sports	85 (35–95)	Sports	85 (52.5–100)	P = 0.330
	QOL	62.5 (50.0–81.3)	QOL	68.8 (46.9–78.1)	P = 0.948

NSS – not statistically significant.

TABLE 5. PATIENT-REPORTED OUTCOME MEASURES — KNEE INJURY AND OSTEOARTHRITIS OUTCOME SCORE, QUALITY OF LIFE[14]

Study	Surgical management		Conservative management		Between-group comparison (95% CI, p-value)
Kvist et al., 2024[14]	20 years	64 (5–70)	20 years	63 (53–72)	P = 0.832
	35 years	58 (49–66)	35 years	59 (48–70)	P = 0.852

TABLE 6. PATIENT-REPORTED OUTCOME MEASURES — INTERNATIONAL KNEE DOCUMENTATION COMMITTEE SUBJECTIVE FORM (IKDC)[10–12]

Study	Surgical management		Conservative management		Between-group comparison (95% CI, p-value)
Tsoukas et al., 2016[12]	86.7 (±6.5)		77.5 (±13)		P = 0.04
Urhausen et al., 2025[11]	86.5 (±11.5)		86.5 (±11.5)		NSS
van Yperen et al., 2018[10]	10 years	77.1 (65.1–87.3)	10 years	77.1 (67.5–84.9)	P = 0.683
	20 years	81.6 (59.8–89.1)	20 years	78.2 (61.5–92.0)	P = 0.442

NSS – not statistically significant.

TABLE 7. PATIENT-REPORTED OUTCOME MEASURES — ANTERIOR CRUCIATE LIGAMENT QUALITY OF LIFE[14]

Study	Surgical management		Conservative management		Between-group comparison (95% CI, p-value)
Kvist et al., 2024[14]	20 years	74 (68–81)	20 years	74 (65–83)	P = 0.964
	35 years	67 (60–74)	35 years	67 (58–76)	P = 0.95

TABLE 8. PATIENT-REPORTED OUTCOME MEASURES — EUROPEAN QOL-5 DIMENSIONS QUESTIONNAIRE AND VISUAL ANALOGUE SCALE[11,14]

Study	Surgical management		Conservative management		Between-group comparison (95% CI, p-value)
	QoL	VAS	QoL	VAS	
Kvist et al., 2024[14]	20 years: 0.849 (0.811–0.886)	20 years: 87 (83–90)	20 years: 0.826 (0.762–0.889)	20 years: 80 (73–88)	P = 0.505 (QoL-5) P = 0.084 (VAS)
	35 years: 0.821 (0.783–0.859)	35 years: 80 (75–85)	35 years: 0.856 (0.806–0.905)	35 years: 81 (76–87)	P = 0.252 (QoL-5) P = 0.619 (VAS)

TABLE 9. PATIENT-REPORTED OUTCOME MEASURES — PATIENT ACCEPTABLE SYMPTOM STATE (PASS)

Study	Surgical management		Conservative management		Between-group comparison (95% CI, p-value)
Urhausen et al., 2025[11]	PASS	80%	PASS	83%	NSS
	Failure	0%	Failure	3%	NSS

NSS – not statistically significant.

TABLE 10. RADIOGRAPHIC OSTEOARTHRITIS (TIBIOFEMORAL OA)

Study	Surgical management		Conservative management		Between-group comparison (95% CI, p-value)
	Total	Grade	Total	Grade	
Tsoukas et al., 2016**,12	14	C–D (23.5%)*	18	C–D (15%)	NSS*
Urhausen et al., 2025***,11	3	≥2	10	≥2	NSS
van Yperen et al., 2018***,10	12 (48%) (10 years)	≥2	7 (28%) (10 years)	≥2	P = 0.508
	20 (80%) (20 years)		17 (68%) (20 years)		

*Not statistically significant. **ROA assessment: IKDC examination score. ***ROA assessment: Kellgren and Lawrence classification.

TABLE 11. RADIOGRAPHIC OSTEOARTHRITIS (PATELLOFEMORAL OA)

Study	Surgical management		Conservative management		Between-group comparison (95% CI, p-value)
	Total	Grade	Total	Grade	
Tsoukas et al., 2016[12]	11	C–D (23.5%)*	9	C–D (15%)	NSS*

*Not statistically significant.

TABLE 12. RE-INJURY AND SECONDARY SURGERIES

Study	Surgical management		Conservative management		Between-group comparison (95% CI, p-value)
Hagmeijer et al., 2019*,15	50 (7%)		63 (19%)		P < 0.01
Melbye et al., 2022**,13	Major	116 (5.9%)	Major	340 (6.1%)	P = 0.729
	Minor	865 (43.9%)	Minor	2,736 (49.1%)	P = 0.0001
van Yperen et al., 2018**,10	4 (16%)		10 (40%)		P = 0.057

*Diagnosed secondary meniscal tear. **Secondary surgeries.

8 Statutory declaration

I herewith declare that I have completed the present report independently, without making use of other than the specified literature and aids. All parts that were taken from published and non-published texts either verbally or in substance are clearly marked as such. This report has not been presented to any examination office in the same form.

Potsdam, 09.01.2026

Matthew Hawke M. Hawke
Christoph Thevessen C. Thevessen

Declaration of consent

I herewith declare my consent to submit my written work electronically. I do consent that the submitted work will be checked by a plagiarism and AI detection software.

Potsdam, 09.01.2026

Matthew Hawke M. Hawke
Christoph Thevessen C. Thevessen