Absorbable vs Nonabsorbable Sutures for Achilles Tendon Repair: A Systematic Review and Meta-analysis

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Abstract

Background: Nonabsorbable sutures are still the main choice for acute Achilles tendon rupture (AATR) repair due to strength provided. However, the rerupture rates, infection risks, foreign body reaction, and postsurgical recovery differences between absorbable and nonabsorbable suture materials in AATR repair have not been carefully reviewed.

Methods: A systematic review was done on PubMed, EBSCO, Cochrane Central Register of Controlled Trials, and Embase to find research studies in relation to complications associated with AATR repair using the PRISMA guidelines. The risk of bias from each study included will be assessed using the Cochrane Risk of Bias Tool for randomized study (RoB 2) and Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I) for nonrandomized study.

Results: Five studies with a total of 255 patients, 105 in the absorbable suture group and 150 in the nonabsorbable suture group, were included for analysis. Risk of rerupture, infection, and foreign body reaction shown no significant difference between groups, and the mean difference of recovery scores were similar.

Conclusion: Existing literature shows that absorbable sutures appear to be associated with similar outcomes to nonabsorbable sutures regarding rates of rerupture, infection, foreign body reaction, and outcomes grading following surgical repair of acute Achilles tendon repair.

Keywords: Achilles, absorbable, suture

Introduction

Acute Achilles tendon rupture (AATR) is a common injury that has a substantial impact on a person's ability to undertake functional activities, particularly in physically active adults.[2] Achilles tendon rupture leads to long-term morbidity, mainly 10% to 30% calf weakness.[2] The primary goals of the management of AATR are to achieve permanent tendon healing at the correct length and to ensure a rapid return to normal function.[16] To date, no clear consensus has been established surrounding the best treatment for AATR. Two main treatments of AATR are surgical vs nonoperative treatment with vigorous debate still ongoing.[3,15]

Choice of suture material for surgical repair of AATR include several options. Surgeons preference are generally prioritized rather than evidence-based choice of suture.[8] Surgeons are generally more in favor of using nonabsorbable, multifilament sutures, believing that the

suture material stays within the repaired tendon and provides adequate fixation power through critical healing period.[1] However, all suture materials can induce an inflammatory reaction with extrinsic scar tissue formation, cause chronic inflammation, and even maintain infection, affecting postoperative outcomes.[1] Absorbable suture material can have initial tendon holding capacity and strength and potentially produce similar postoperative functional outcomes compared to nonabsorbable

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suture material,[5] and it carries the potential advantage of ultimately being resorbed from the site.[13] The purpose of this study was to perform a systematic review and meta-analysis comparing usage of absorbable and nonabsorbable suture in Achilles tendon repair.

Methods

Eligibility Criteria

The inclusion criteria for this systematic review were (1) clinical trial or cohort study design, (2) reported comparison of absorbable and nonabsorbable sutures in the treatment of AATRs, (3) full-text studies, and (4) available in English. The exclusion criteria were (1) animal studies, (2) cadaveric studies, (3) in vitro studies, and (4) reviews.

Search Strategy, Information Source, and Selection Process

This systematic review is conducted by 2 authors (I.O., A.F.C.) on PubMed, EBSCO, Cochrane Central Register of Controlled Trials, and Embase in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines.[11] The search terms were as follows: (Achilles tendon OR tendoachilles OR tendo Achilles OR tendoachillis OR tendo Achillis OR calcaneal tendon OR tendocalcaneus OR tendo calcaneus) AND (treatment OR intervention OR management OR repair) AND (suture OR sutures OR absorbable OR nonabsorbable). The titles, abstracts, and full text identified by the search terms were screened according to specific eligibility criteria.

Quality Assessment

The risk of bias from each study included will be assessed using the Cochrane Risk of Bias Tool[6] for randomized study (RoB 2) and Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I)[10] for nonrandomized study by 2 authors (I.O., A.F.C.) independently and disagreement were resolved by discussion. Level of evidence was assessed using Levels of Evidence for Primary Research Question by Wright.[17]

Data extraction. All baseline demographics data were extracted from included studies, consisting of author names, year of publication, country in which the study was performed, study design, and number of included patients. Collected data are then categorized into open repair with absorbable sutures group and nonabsorbable sutures group. The outcomes collected were scoring and complications related to meta-focus, analysis, including recovery score

assessment, infection, foreign body reaction rates, ankle joint limitation, and VAS score to assess pain and are displayed in tables. Infection, foreign body reaction rates, and ankle joint limitation will be assessed categorically whereas the recovery score numerically.

Statistical Analysis

Statistical analyses were performed using RevMan version 5.4 (Cochrane Collaboration). Risk differences and 95% CIs were calculated for dichotomous outcomes and mean differences and 95% CIs were calculated for continuous outcomes. Heterogeneity was evaluated by the chi-square test, which described the percentage of total variation across studies that was due to heterogeneity rather than chance. The random effects model or subgroup analysis would be chosen to perform the meta-analysis if the data were heterogeneous; otherwise, the fixed effects model would be selected. The I^2 values were calculated as an objective basis of heterogeneity judgment. The P value from the chi-square test was required to be $<.05$ and $I^2 > 50\%$.

Results

Literature Search

A total of 1190 citations from PubMed, 856 from EBSCO, 16 from Cochrane, and 25 from Embase were acquired through the literature search (Table 1). We excluded 296 duplicate citations by using Mendeley duplicate remover. After screening, 1785 citations were excluded. One animal study was excluded. In the end, 5 studies were included in this meta-analysis. Three studies were randomized clinical studies, whereas the other 2 were nonrandomized studies. The PRISMA flowchart of this meta-analysis is displayed in Figure 1. Quality assessment of randomized studies using RoB 2 (Figure 2) and nonrandomized studies using ROBINS-I (Figure 3) concludes low risk of bias in all studies included. A common bias found across articles was the blinding of intervention from the intervener (surgeons), which was impossible. Details of patient's characteristics and demographics are presented in Table 2.

Rate of Rerupture

No heterogeneity was found in studies regarding the rate of rerupture ($P=0.96$; $I^2=0\%$), therefore fixed effects model was used. Those in the absorbable suture group did not experience any significant difference on rerupture rate than patients in the nonabsorbable group (risk difference: 0.01, 95% CI −0.04 to 0.06; $P=.60$) (Figure 4). The percentage of rerupture in the absorbable suture group was 2.33% (2 of 86), and in the nonabsorbable group, 0.76% (1 of 132).
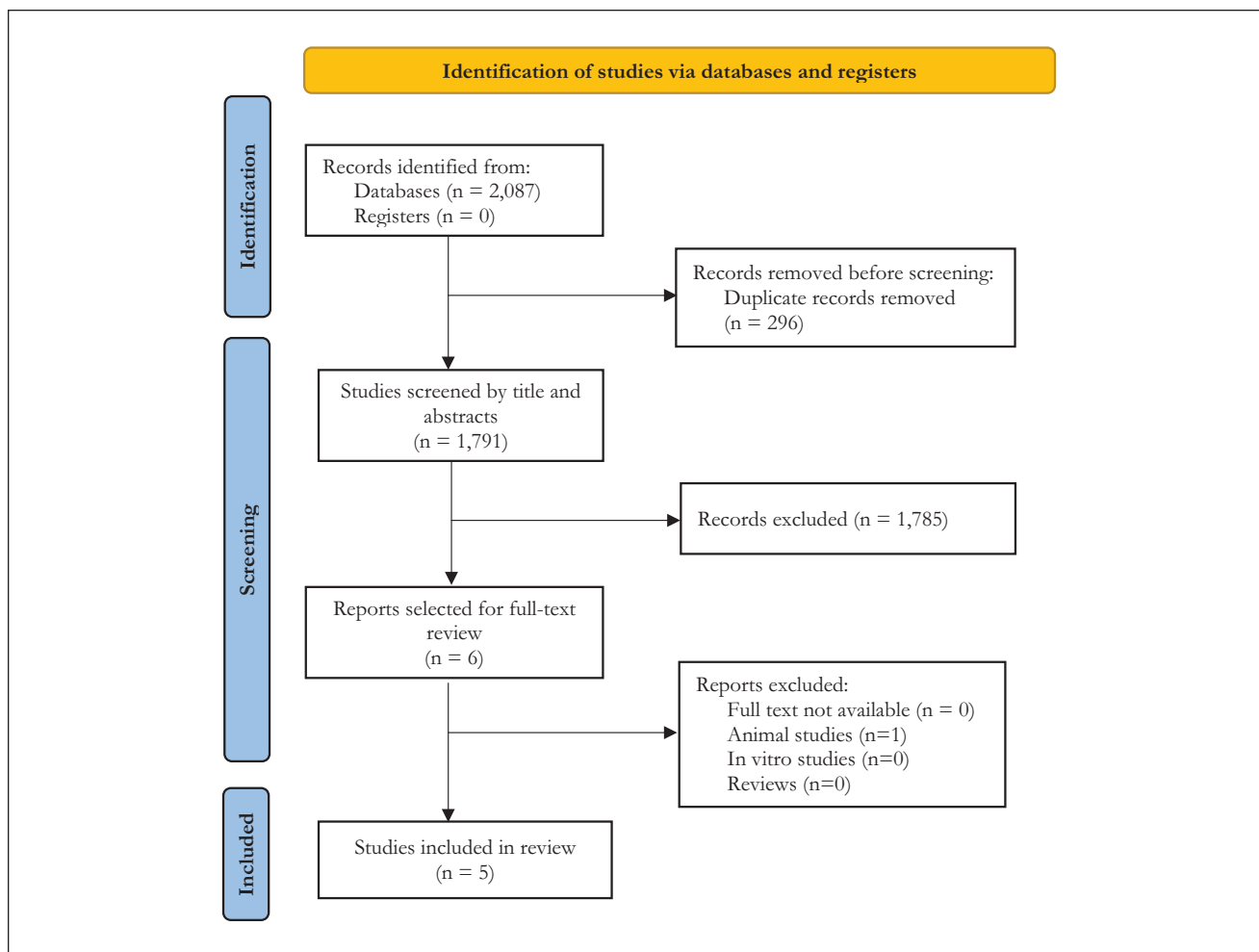
Figure 1. PRISMA flowchart of this meta-analysis.

Table 1. Keywords Used in Literature Search.

Database	Keywords	Results
PubMed	("Achilles tendon" OR "tendoachilles" OR "tendo Achilles" OR tendoachillis OR "tendo Achillis" OR	1190
EBSCO	"calcaneal tendon" OR "tendocalcaneus" OR "tendo calcaneus") AND ("treatment" OR "intervention"	856
Cochrane	OR "management" OR "repair") AND ("suture" OR "sutures" OR "absorbable" OR "non-absorbable")	16
Embase		25

Rate of Infection

Fixed effect model was used as no heterogeneity was found in studies of infection rate ($P = .86$; $I^2 = 0\%$). Patients in the absorbable suture group had no significantly different event of infection than patients in the nonabsorbable group (risk difference 0.01, 95% CI −0.06 to 0.08; $P = .81$) (Figure 5). Infection in the absorbable suture group reached 7.62% (8 of 105) and 8.67% in nonabsorbable group (13 of 150).

Rate of Foreign Body Reaction

Rates of foreign body reaction in the included studies showed no heterogeneity ($P = .62$; $I^2 = 0\%$); that being the case, fixed effects model was used. Events assessed in Ji et al[6] were adhesion rates resulting from inflammation and the coagulation process. Results showed that patients in the nonabsorbable sutures group had no significantly different foreign body reaction than patients in the absorbable suture group (risk difference −0.02, 95% CI −0.11 to 0.07; $P = .69$)
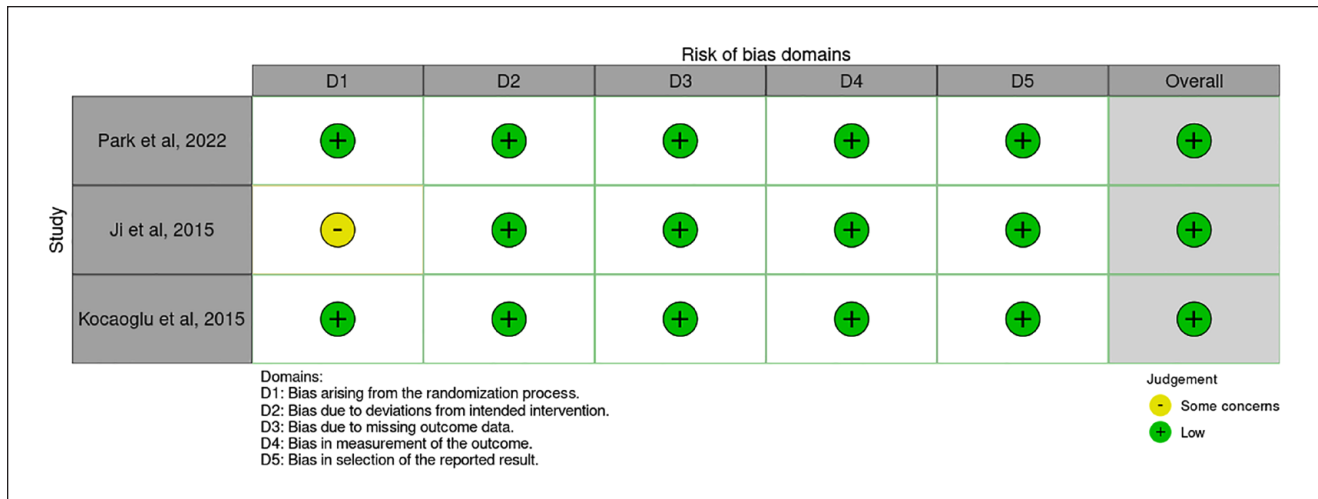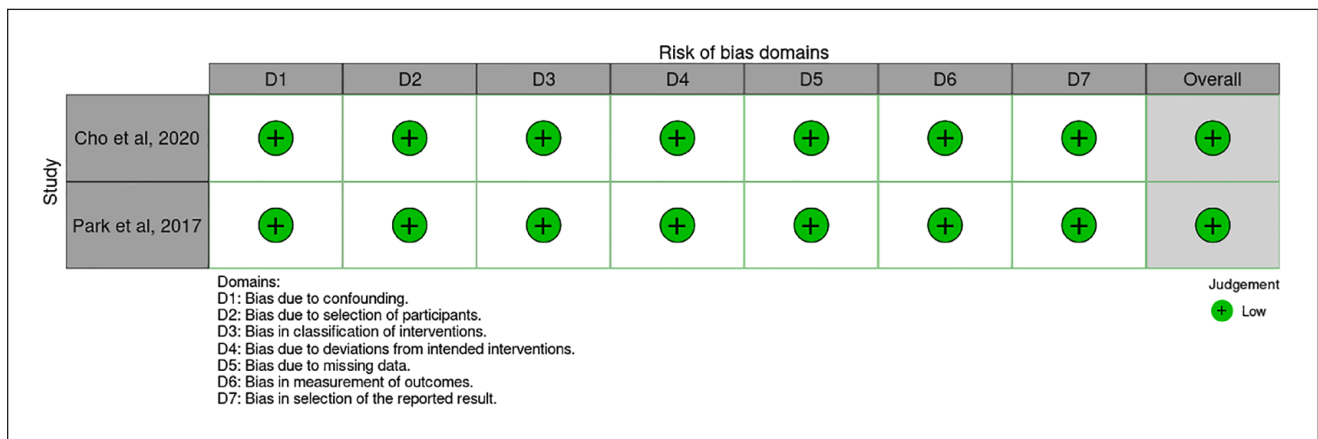
Figure 2. Risk of bias summary using RoB 2.

Figure 3. Risk of bias summary using ROBINS-I.

Table 2. Characteristics of the Included Studies.[a]

Author(s)	Publication year	Country	Study design	Level of evidence	Sample size A	B	Sex (M/F) A	B	Mean age (y) A	B	BMI A	B	Injured side (R/L) A	B	Mechanism of injury (S/N) A	B
Park et al[14]	2022	South Korea	Prospective RCT	I	19	18	15/4	16/1	39.2	41.9	24.9	26.6	10/9	10/7	16/3	14/3
Cho et al[5]	2020	South Korea	Nonrandomized retrospective study	III	11	11	9/2	9/2	41.73	40.18	26.11	25.75	NM	NM	NM	NM
Park et al[13]	2017	South Korea	Nonrandomized prospective study	II	10	10	9/1	10/0	42.4	40.9	23.8	23.6	NM	NM	NM	NM
Ji et al[6]	2015	China	RCT	I	41	87	32/9	63/24	45.3	44.7	NM	NM	18/23	35/52	38/3	75/12
Kocaoglu et al[10]	2015	Turkey	RCT	I	24	24	NM	NM	38	38	NM	NM	NM	NM	NM	NM

Abbreviations: NM, not mentioned; N, nonsport injury; RCT, randomize controlled trial; S, sport injury.
[a]Group A = open repair with absorbable suture; group B = open repair with nonabsorbable suture.
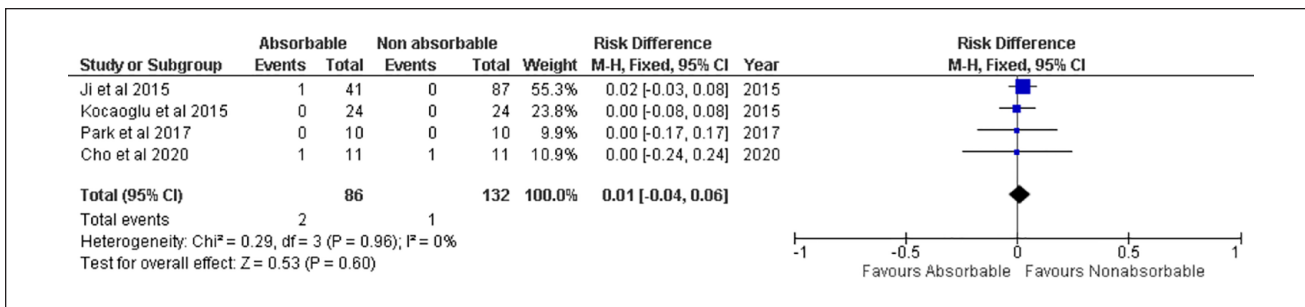
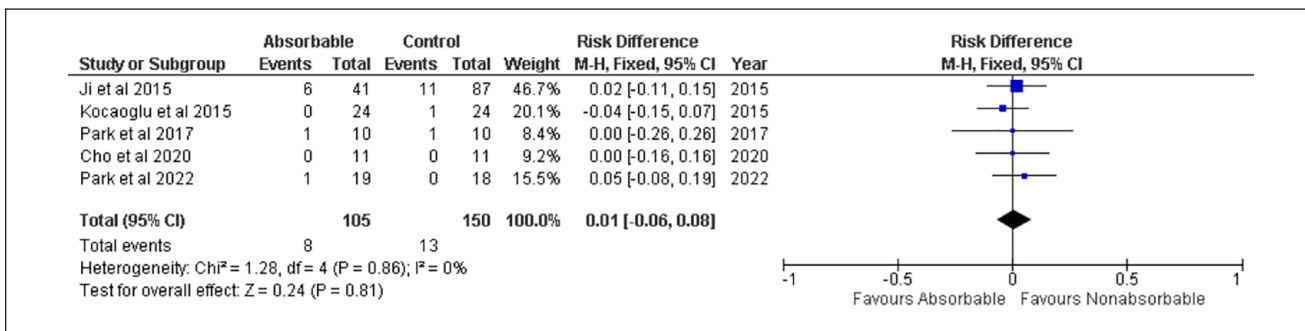**Figure 4.** Forest plot showing rerupture rate after repair with absorbable vs nonabsorbable sutures.

Figure 5. Forest plot showing infection rate after repair with absorbable vs nonabsorbable sutures.
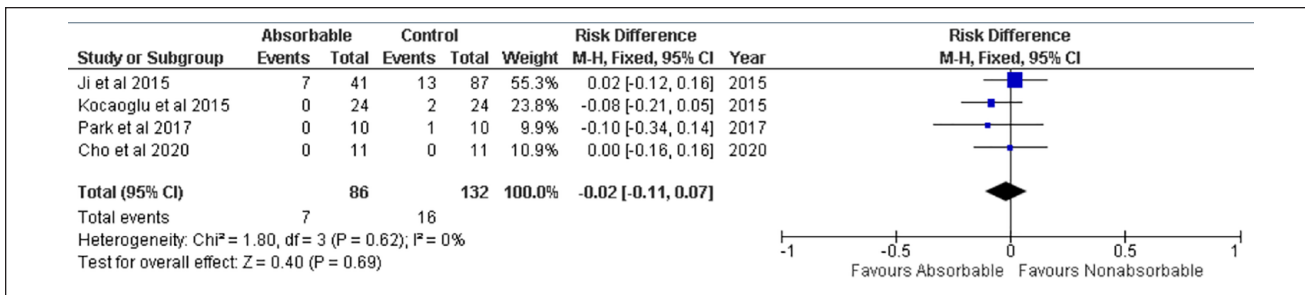

Figure 6. Forest plot showing foreign body reaction rate after repair with absorbable vs nonabsorbable sutures.

(Figure 6). Foreign body reaction rate in the absorbable suture group was 8.13% (7 of 86), and in the nonabsorbable group, 12.12% (16 of 132).

Difference in Mean Recovery Score

Heterogeneity was seen in studies concerning scoring of recovery in the studies ($P = .002$, $I^2 = 82\%$). The studies mainly use American Orthopaedic Foot & Ankle Society ankle-hindfoot score to evaluate recovery in each patient. Unlike the other included studies, Park et al[14] used Achilles tendon Total Rupture Score (ATRS) and Park et al[13] assessed patients using scoring from Foot and Ankle Outcome Score

(FAOS), all recording recovery score of patients after surgery, with scores ranging from 0 to 100 (Figure 7). The mean difference in recovery outcome scores displayed too much heterogeneity to allow pooling of the data.

Discussion

This study was intended to identify potential superiority between absorbable and nonabsorbable sutures used for Achilles tendon repair after rupture. We found that patients in the absorbable suture group experienced no significantly different rerupture rate than patients in the nonabsorbable group. A study of Park et al[14] is that isokinetic
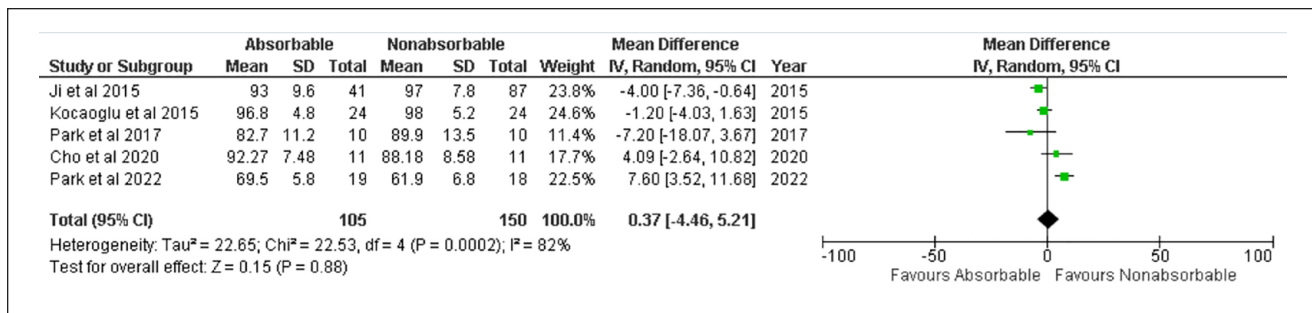
Figure 7. Forest plot showing recovery score after repair with absorbable vs nonabsorbable sutures.

plantar flexion strength between the absorbable and the nonabsorbable suture groups showed no significant difference. Despite mechanical studies' findings that absorbable sutures have a lower load-to-failure property than nonabsorbable sutures over time, the clinical outcomes evaluated in our study for absorbable and nonabsorbable sutures were comparable.

Infection rates in both absorbable and nonabsorbable sutures group were similar. Incidence rate of infection after surgical repair of AATR was reported to be 2% to 3%.[7,12] Infections regarding surgery site was known to have several risk factors, including corticosteroid use, smoking, diabetes, and delay in treatment.[12] A study by Jildeh et al[7] showed that those with longer tourniquet times, higher estimated blood loss, and a history of smoking had a higher infection risk.

Our results found no significant differences in the rate of foreign body reaction to absorbable suture group than the nonabsorbable group. Absorbable stitches usually disappear within an average of 3 months. Some reports found foreign body granulomatous reaction associated with nonabsorbable suture material used in AATR repair.[13] Absorbable sutures may allow AATR repair because of its low rate of reaction, especially after absorption.[4] This process is usually delayed in onset and would appear in a few months after the surgery.[9]

This study has several limitations. First of all, this study includes nonrandomized studies, which may affect the results. Heterogeneity across study designs and variables also limits performing meta-analysis in difference in recovery. This includes exact suture type and size, repair method, postoperative protocol, intervals, and length of follow-up. Risk ratio of outcomes can be influenced by other nonmodifiable factors including preoperative Achilles tendon status and patient baseline characteristics and comorbidities. Several outcomes are also not fully reported in the selected papers as only some outcomes were recorded, which may be due to the limited number of participants.

Conclusions

The use of absorbable and nonabsorbable sutures seems to have no significant difference in impact regarding rerupture, infection, foreign body reaction rate, and outcome scoring post AATR surgery repair. Further larger prospective studies regarding the outcome of absorbable sutures on AATR are warranted.

Ethical Approval

Ethical approval was not sought for the present study as this is a systematic review and meta-analysis.

Declaration of Conflicting Interests

Funding

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References

1. Barber FA, Herbert MA, Richards DP. Sutures and suture anchors: update 2003. *Arthroscopy*. 2003;19(9):985-990. doi:10.1016/j.arthro.2003.09.018

2. Barfod KW, Sveen TM, Ganestam A, Ebskov LB, Troelsen A. Severe functional debilitations after complications associated with acute Achilles tendon rupture with 9 years of follow-up. *J Foot Ankle Surg*. 2017;56(3):440-444. doi:10.1053/j.jfas.2017.01.004

3. Bistolfi A, Zanovello J, Lioce E, et al. Achilles tendon injuries: comparison of different conservative and surgical treatment and rehabilitation. *J Nov Physiother Rehabil*. 2017;1:39-53.

4. Campillo-Recio D, Comas-Aguilar M, Ibáñez M, Maldonado-Sotoca Y, Albertí-Fitó G. Percutaneous Achilles tendon repair with absorbable suture: outcomes and complications. *Rev*

Esp Cir Ortop Traumatol. 2023;67(1):56-61. doi:10.1016/J.RECOT.2022.06.008

5. Cho J, Kim HJ, Lee JS, et al. Comparing absorbable and nonabsorbable suture materials for repair of ACHILLES tendon rupture: a magnetic resonance imaging-based study. *Diagnostics*. 2020;10(12):1-11. doi:10.3390/diagnostics10121085

6. Ji Y, Ma X, Wang X, Huang J, Zhang C, Chen L. Different sutures in the surgical treatment of acute closed Achilles tendon rupture. *Indian J Surg*. 2015;77(Suppl 3):936-940. doi:10.1007/s12262-014-1068-8

7. Jildeh TR, Okoroha KR, Marshall NE, Abdul-Hak A, Zeni F, Moutzouros V. Infection and rerupture after surgical repair of Achilles tendons. *Orthop J Sports Med*. 2018;6(5):2325967118774302. doi:10.1177/2325967118774302

8. Kangas J, Pajala A, Ohtonen P, Leppilahti J. Achilles tendon elongation after rupture repair: a randomized comparison of 2 postoperative regimens. *Am J Sports Med*. 2007;35(1):59-64. doi:10.1177/0363546506293255

9. Kim J, Kang HJ, Kim BS, et al. Clinical features and treatment of intra-tendinous suture reaction following Achilles tendon repair using nonabsorbable suture material: a retrospective case series study. *Int J Environ Res Public Health*. 2022;19(19):12897. doi:10.3390/IJERPH191912897

10. Kocaoglu B, Ulku TK, Gereli A, Karahan M, Turkmen M. Evaluation of absorbable and nonabsorbable sutures for repair of Achilles tendon rupture with a suture-guiding device. *Foot Ankle Int*. 2015;36(6):691-695. doi:10.1177/1071100714568868

11. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Syst Rev*. 2021;10(1):89. doi:10.1186/s13643-021-01626-4

12. Pajala A, Kangas J, Ohtonen P, Leppilahti J. Rerupture and deep infection following treatment of total Achilles tendon rupture. *J Bone Joint Surg Am*. 2002;84(11):2016-2021. doi:10.2106/00004623-200211000-00017

13. Park JH, Chun DI, Lee SH, Cho JH. A comparative evaluation of absorbable and nonabsorbable sutures for open repair of Achilles tendon rupture: a pilot study. *Korean J Phys Anthropol*. 2017;30(2):39-46. doi:10.11637/KJPA.2017.30.2.39

14. Park YH, Kim W, Choi JW, Kim HJ. Absorbable versus nonabsorbable sutures for the Krackow suture repair of acute Achilles tendon rupture: a prospective randomized controlled trial. *Bone Joint J*. 2022;104-B(8):938-945. doi:10.1302/0301-620X.104B8.BJJ-2021-1730.R2

15. She G, Teng Q, Li J, Zheng X, Chen L, Hou H. Comparing surgical and conservative treatment on Achilles tendon rupture: a comprehensive meta-analysis of RCTs. *Front Surg*. 2021;8:607743. doi:10.3389/FSURG.2021.607743

16. Yang X, Meng H, Quan Q, Peng J, Lu S, Wang A. Management of acute Achilles tendon ruptures. *Bone Joint Res*. 2018;7(10):561-569. doi:10.1302/2046-3758.710.BJR-2018-0004.R2

17. Wright JG. Levels of evidence and grades of recommendations: An evaluation of literature. Evidence-based practice: A primer; 2005;16-7.

Appendix

Risk of Bias Assessment

1. Park et al,[13] Using the RoB 2

- Domain 1: Risk of Bias Arising From the Randomization Process

Signaling Questions	Comments	Response Options
1.1. Was the allocation sequence random?	Each patient was randomly allocated to either group A (absorbable) and B (nonabsorbable) using computer software (Excel 2016; Microsoft, USA)	Yes
1.2. Was the allocation sequence concealed until participants were enrolled and assigned to interventions?	The randomization sequence is done by the study coordinator, who did not participate in the surgical procedures and outcome assessments and sealed in opaque envelopes. Those who assessed the outcomes and performed the statistical analyses were blinded to the allocations.	Yes
1.3. Did baseline differences between intervention groups suggest a problem with the randomization process?	Kolmogorov-Smirnov tests were used to evaluate the normality of the data distributions; result is not included in the article	Probably no
Risk-of-bias judgment	Low risk of bias	

- Domain 2: Risk of Bias due to Deviations From the Intended Interventions (Effect of Assignment to Intervention)

Signaling Questions	Comments	Response Options
2.1. Were participants aware of their assigned intervention during the trial?	Patients did not know which group they were assigned to, but the surgeon could not be blinded to the group allocation.	No
2.2. Were carers and people delivering the intervention aware of participants' assigned intervention during the trial?		Yes
2.3. If Y/PY/NI to 2.2: Were there deviations from the intended intervention that arose because of the trial context?	There is a deviation from study protocol in 1 patient, no further explanation	Yes
2.4. If Y/PY to 2.3: Were these deviations likely to have affected the outcome?	Patient is excluded	No
2.5. If Y/PY/NI to 2.4: Were these deviations from intended intervention balanced between groups?	Not assessed	
2.6. Was an appropriate analysis used to estimate the effect of assignment to intervention?	Patients with missing outcome are excluded	Yes
2.7. If N/PN/NI to 2.6: Was there potential for a substantial impact (on the result) of the failure to analyze participants in the group to which they were randomized?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Domain 3: Risk of Bias due to Missing Outcome Data

Signaling Questions	Comments	Response Options
3.1. Were data for this outcome available for all, or nearly all, participants randomized?	Nearly all participants' outcomes are available, except for the missing data in 12-mo follow-up	Yes
3.2. If N/PN/NI to 3.1: Is there evidence that the result was not biased by missing outcome data?	Not assessed	
3.3. If N/PN to 3.2: Could missingness in the outcome depend on its true value?	Not assessed	
3.4. If Y/PY/NI to 3.3: Is it likely that missingness in the outcome depended on its true value?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Domain 4: Risk of Bias in Measurement of the Outcome

Signaling Questions	Comments	Response Options
4.1. Was the method of measuring the outcome inappropriate?	Outcomes are prespecified and measured with validated and calibrated assessment tools	No
4.2. Could measurement or ascertainment of the outcome have differed between intervention groups?	Both groups have the same measurement of outcomes	No
4.3. If N/PN/NI to 4.1 and 4.2: Were outcome assessors aware of the intervention received by study participants?	Not assessed	
4.4. If Y/PY/NI to 4.3: Could assessment of the outcome have been influenced by knowledge of intervention received?	Not assessed	
4.5. If Y/PY/NI to 4.4: Is it likely that assessment of the outcome was influenced by knowledge of intervention received?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Domain 5: Risk of Bias in Selection of the Reported Result

Signaling Questions	Comments	Response Options
5.1. Were the data that produced this result analyzed in accordance with a prespecified analysis plan that was finalized before unblinded outcome data were available for analysis?	Researchers' prespecified intentions are available in sufficient detail	Yes
Is the numerical result being assessed likely to have been selected, on the basis of the results, from . . .		
5.2. . . . multiple eligible outcome measurements (eg, scales, definitions, time points) within the outcome domain?	Outcome measurements are not assessed using multiple instruments	No
5.3. . . . multiple eligible analyses of the data?	Outcome measurements are not analyzed in multiple ways.	No
Risk-of-bias judgment	Low risk of bias	

Overall risk of bias: low risk of bias.

2. *Cho et al,[5] Using ROBINS-I*

- Preintervention Domain 1 : Bias due to Confounding

Signaling Questions	Comments	Response Options
1.1. Is there potential for confounding of the effect of intervention in this study?	Patients with confounding factors are excluded from participating in this study	No
If Y/PY to 1.1: determine whether there is a need to assess time-varying confounding:	Not assessed	
1.2. Was the analysis based on splitting participants' follow-up time according to intervention received?		
If N/PN, answer questions relating to baseline confounding (1.4 to 1.6)		
If Y/PY, go to question 1.3.		
1.3. Were intervention discontinuations or switches likely to be related to factors that are prognostic for the outcome?	Not assessed	
If N/PN, answer questions relating to baseline confounding (1.4 to 1.6)		
If Y/PY, answer questions relating to both baseline and time-varying confounding (1.7 and 1.8)		
Questions relating to baseline confounding only		
1.4. Did the authors use an appropriate analysis method that controlled for all the important confounding domains?	Not assessed	
1.5. If Y/PY to 1.4: Were confounding domains that were controlled for measured validly and reliably by the variables available in this study?	Not assessed	
1.6. Did the authors control for any postintervention variables that could have been affected by the intervention?	Not assessed	
Questions relating to baseline and time-varying confounding		
1.7. Did the authors use an appropriate analysis method that controlled for all the important confounding domains and for time-varying confounding?	Not assessed	
1.8. If Y/PY to 1.7: Were confounding domains that were controlled for measured validly and reliably by the variables available in this study?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Preintervention Domain 2 : Bias in Selection of Participants Into the Study

Signaling Questions	Comments	Response Options
2.1. Was selection of participants into the study (or into the analysis) based on participant characteristics observed after the start of intervention? If N/PN to 2.1: go to 2.4	Selection process was done before the start of intervention	No
2.2. If Y/PY to 2.1: Were the postintervention variables that influenced selection likely to be associated with intervention?	Not assessed	
2.3. If Y/PY to 2.2: Were the postintervention variables that influenced selection likely to be influenced by the outcome or a cause of the outcome?	Not assessed	
2.4. Do start of follow-up and start of intervention coincide for most participants?	Patients are treated <1 wk after injury and followed for minimum of 6 mo after surgery	Yes
2.5. If Y/PY to 2.2 and 2.3, or N/PN to 2.4: Were adjustment techniques used that are likely to correct for the presence of selection biases?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- At Intervention Domain 3 : Bias in Classification of Interventions

Signaling Questions	Comments	Response Options
3.1. Were intervention groups clearly defined?	Patients were allocated into 2 groups in terms of the suture materials used to perform the core suture	Yes
3.2. Was the information used to define intervention groups recorded at the start of the intervention?	Two groups are defined clearly at start of intervention	Yes
3.3 Could classification of intervention status have been affected by knowledge of the outcome or risk of the outcome?	Classification is not affected by knowledge or risk	No
Risk-of-bias judgment	Low risk of bias	

- Postintervention Domain 4 : Bias due to Deviations From Intended Interventions

Signaling Questions	Comments	Response Options
4.1. Were there deviations from the intended intervention beyond what would be expected in usual practice?	Procedures are performed similarly	No
4.2. If Y/PY to 4.1: Were these deviations from intended intervention unbalanced between groups and likely to have affected the outcome?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Postintervention Domain 5 : Bias due to Missing Data

Signaling Questions	Comments	Response Options
5.1. Were outcome data available for all, or nearly all, participants?	Four (26.7% of participants) participants are not followed up	No
5.2. Were participants excluded because of missing data on intervention status?	Participants excluded because of declining to MRI and loss to follow-up	No
5.3 Were participants excluded because of missing data on other variables needed for the analysis?		No
5.4. If PN/N to 5.1, or Y/PY to 5.2 or 5.3: Are the proportion of participants and reasons for missing data similar across interventions?	Each group had 4 missing data each	No
5.5. If PN/N to 5.1, or Y/PY to 5.2 or 5.3: Is there evidence that results were robust to the presence of missing data?	There is no clear information regarding robustness of results	Not informed
Risk-of-bias judgment	Low risk of bias	

- Postintervention Domain 6 : Bias in Measurement of Outcomes

Signaling Questions	Comments	Response Options
6.1. Could the outcome measure have been influenced by knowledge of the intervention received?	Outcomes include all-cause mortality or nonrepeatable automated laboratory assessments	No
6.2. Were outcome assessors aware of the intervention received by study participants?	Images were independently evaluated by 2 fellowship-trained orthopaedic surgeons who had 10 and 5 years of experience, respectively, but not informed about the intervention	Not informed
6.3 Were the methods of outcome assessment comparable across intervention groups?	Outcomes measured are same in terms of methods and thresholds, same time point, same definition, and same measurements	No
6.4. Were any systematic errors in measurement of the outcome related to intervention received?	There is no differential misclassification of outcomes	No
Risk-of-bias judgment	Low risk of bias	

- Postintervention Domain 7: Bias in Selection of the Reported Result

Signaling Questions	Comments	Response Options
Is the reported effect estimate likely to be selected, on the basis of the results, from . . .		
7.1. . . . multiple outcome measurements within the outcome domain?	No multiple outcome measurements are done	No
7.2. . . . multiple analyses of the intervention-outcome relationship?	No multiple analyses of measurements are done	No
7.3. . . . different subgroups?	No subgroups	No
Risk-of-bias judgment	Low risk of bias	

Overall risk of bias: low risk of bias.

3. *Park et al,[13] Using ROBINS-I*

- Preintervention Domain 1 : Bias due to Confounding

Signaling Questions	Comments	Response Options
1.1. Is there potential for confounding of the effect of intervention in this study?	Patients with confounding factors are excluded from participating in this study	No
If Y/PY to 1.1: determine whether there is a need to assess time-varying confounding: 1.2. Was the analysis based on splitting participants' follow-up time according to intervention received? If N/PN, answer questions relating to baseline confounding (1.4 to 1.6) If Y/PY, go to question 1.3.	Not assessed	
1.3. Were intervention discontinuations or switches likely to be related to factors that are prognostic for the outcome? If N/PN, answer questions relating to baseline confounding (1.4 to 1.6) If Y/PY, answer questions relating to both baseline and time-varying confounding (1.7 and 1.8)	Not assessed	
Questions relating to baseline confounding only		
1.4. Did the authors use an appropriate analysis method that controlled for all the important confounding domains?	Not assessed	
1.5. If Y/PY to 1.4: Were confounding domains that were controlled for measured validly and reliably by the variables available in this study?	Not assessed	
1.6. Did the authors control for any postintervention variables that could have been affected by the intervention?	Not assessed	
Questions relating to baseline and time-varying confounding		
1.7. Did the authors use an appropriate analysis method that controlled for all the important confounding domains and for time-varying confounding?	Not assessed	
1.8. If Y/PY to 1.7: Were confounding domains that were controlled for measured validly and reliably by the variables available in this study?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Preintervention Domain 2 : Bias in Selection of Participants Into the Study

Signaling Questions	Comments	Response Options
2.1. Was selection of participants into the study (or into the analysis) based on participant characteristics observed after the start of intervention? If N/PN to 2.1: go to 2.4	Selection process was done before the start of intervention	No
2.2. If Y/PY to 2.1: Were the postintervention variables that influenced selection likely to be associated with intervention?	Not assessed	
2.3 If Y/PY to 2.2: Were the postintervention variables that influenced selection likely to be influenced by the outcome or a cause of the outcome?	Not assessed	
2.4. Do start of follow-up and start of intervention coincide for most participants?	Patients are treated <1 wk after injury and followed for minimum of 6 mo after surgery	Yes
2.5. 2.5. If Y/PY to 2.2 and 2.3, or N/PN to 2.4: Were adjustment techniques used that are likely to correct for the presence of selection biases?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- At Intervention Domain 3 : Bias in Classification of Interventions

Signaling Questions	Comments	Response Options
3.1. Were intervention groups clearly defined?	Patients were allocated into 2 groups in terms of the suture materials used to perform the core suture	Yes
3.2. Was the information used to define intervention groups recorded at the start of the intervention?	Two groups are defined clearly at start of intervention	Yes
3.3 Could classification of intervention status have been affected by knowledge of the outcome or risk of the outcome?	Classification is not affected by knowledge or risk	No
Risk-of-bias judgment	Low risk of bias	

- Postintervention Domain 4: Bias due to Deviations From Intended Interventions

Signaling Questions	Comments	Response Options
4.1. Were there deviations from the intended intervention beyond what would be expected in usual practice?	Procedures are performed similarly	No
4.2. If Y/PY to 4.1: Were these deviations from intended intervention unbalanced between groups and likely to have affected the outcome?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Postintervention Domain 5: Bias due to Missing Data

Signaling Questions	Comments	Response Options
5.1. Were outcome data available for all, or nearly all, participants?	Outcome data for all participants are available	Yes
5.2. Were participants excluded because of missing data on intervention status?	No missing data on intervention status	No
5.3. Were participants excluded because of missing data on other variables needed for the analysis?	No missing data on intervention status	No
5.4. If PN/N to 5.1, or Y/PY to 5.2 or 5.3: Are the proportion of participants and reasons for missing data similar across interventions?	Not assessed	
5.5. If PN/N to 5.1, or Y/PY to 5.2 or 5.3: Is there evidence that results were robust to the presence of missing data?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Postintervention Domain 6: Bias in Measurement of Outcomes

Signaling Questions	Comments	Response Options
6.1. Could the outcome measure have been influenced by knowledge of the intervention received?	Outcomes include all-cause mortality or nonrepeatable automated laboratory assessments	No
6.2. Were outcome assessors aware of the intervention received by study participants?	Outcome are measured by one doctor not participating in surgeries	No
6.3 Were the methods of outcome assessment comparable across intervention groups?	Outcomes measured are same in terms of methods and thresholds, same time point, same definition, and same measurements	No
6.4. Were any systematic errors in measurement of the outcome related to intervention received?	There is no differential misclassification of outcomes	No
Risk-of-bias judgment	Low risk of bias	

- Postintervention Domain 7 : Bias in Selection of the Reported Result

Signaling Questions	Comments	Response Options
Is the reported effect estimate likely to be selected, on the basis of the results, from. . .		
7.1. . . . multiple outcome measurements within the outcome domain?	No multiple outcome measurements are done	No
7.2. . . . multiple analyses of the intervention-outcome relationship?	No multiple analyses of measurements are done	No
7.3. . . . different subgroups?	No subgroups	
Risk-of-bias judgment	Low risk of bias	

Overall risk of bias: low risk of bias.

4. Ji et al,[6] Using the RoB 2

- Domain 1: Risk of Bias Arising From the Randomization Process

Signaling Questions	Comments	Response Options
1.1. Was the allocation sequence random?	Each patient was randomly allocated to either PDS II suture/absorbable (group A) and the Ethibond suture/nonabsorbable (group B)	Yes
1.2. Was the allocation sequence concealed until participants were enrolled and assigned to interventions?	No clear information were stated	No information
1.3. Did baseline differences between intervention groups suggest a problem with the randomization process?	No clear information were stated	No information
Risk-of-bias judgment	Some concerns of bias	

- Domain 2: Risk of Bias due to Deviations From the Intended Interventions (Effect of Assignment to Intervention)

Signaling Questions	Comments	Response Options
2.1. Were participants aware of their assigned intervention during the trial?	Patients probably had no idea which group they were assigned to	Probably no
2.2. Were carers and people delivering the intervention aware of participants' assigned intervention during the trial?	Surgeons will know which sutures they are using in each surgery	Yes
2.3. If Y/PY/NI to 2.2: Were there deviations from the intended intervention that arose because of the trial context?	There is no deviations from the intended intervention	No
2.4. If Y/PY to 2.3: Were these deviations likely to have affected the outcome?	Not assessed	
2.5. If Y/PY/NI to 2.4: Were these deviations from intended intervention balanced between groups?	Not assessed	
2.6. Was an appropriate analysis used to estimate the effect of assignment to intervention?	Patients with missing outcome are excluded	Yes
2.7. If N/PN/NI to 2.6: Was there potential for a substantial impact (on the result) of the failure to analyze participants in the group to which they were randomized?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Domain 3: Risk of Bias due to Missing Outcome Data

Signaling Questions	Comments	Response Options
3.1 Were data for this outcome available for all, or nearly all, participants randomized?	Nearly all participants' outcomes are available	Yes
3.2 If N/PN/NI to 3.1: Is there evidence that the result was not biased by missing outcome data?	Not assessed	
3.3 If N/PN to 3.2: Could missingness in the outcome depend on its true value?	Not assessed	
3.4 If Y/PY/NI to 3.3: Is it likely that missingness in the outcome depended on its true value?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Domain 4: Risk of Bias in Measurement of the Outcome

Signaling Questions	Comments	Response Options
4.1. Was the method of measuring the outcome inappropriate?	Outcomes are prespecified and measured with validated and calibrated assessment tools	No
4.2. Could measurement or ascertainment of the outcome have differed between intervention groups?	Both groups have the same measurement of outcomes	No
4.3. If N/PN/NI to 4.1 and 4.2: Were outcome assessors aware of the intervention received by study participants?	Not assessed	
4.4. If Y/PY/NI to 4.3: Could assessment of the outcome have been influenced by knowledge of intervention received?	Not assessed	
4.5. If Y/PY/NI to 4.4: Is it likely that assessment of the outcome was influenced by knowledge of intervention received?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Domain 5: Risk of Bias in Selection of the Reported Result

Signaling Questions	Comments	Response Options
5.1 Were the data that produced this result analyzed in accordance with a prespecified analysis plan that was finalized before unblinded outcome data were available for analysis?	Researchers' prespecified intentions are available in sufficient detail	Yes
Is the numerical result being assessed likely to have been selected, on the basis of the results, from. . .		
5.2. . . . multiple eligible outcome measurements (eg, scales, definitions, time points) within the outcome domain?	Outcome measurements are not assessed using multiple instruments	No
5.3 . . . multiple eligible analyses of the data?	Outcome measurements are not analyzed in multiple ways.	No
Risk-of-bias judgment	Low risk of bias	

Overall risk of bias: low risk of bias.

5. *Kocaoglu et al,[10] using the RoB 2*

- Domain 1: Risk of Bias Arising From the Randomization Process

Signaling Questions	Comments	Response Options
1.1. Was the allocation sequence random?	Each patient was randomly allocated to either the nonabsorbable suture (group A) or absorbable suture group (group B)	Yes
1.2. Was the allocation sequence concealed until participants were enrolled and assigned to interventions?	Patients are not informed regarding the randomization	Yes
1.3. Did baseline differences between intervention groups suggest a problem with the randomization process?	No clear information were stated	No information
Risk-of-bias judgment	Low risk of bias	

- Domain 2: Risk of Bias Due to Deviations From the Intended Interventions (Effect of Assignment to Intervention)

Signaling Questions	Comments	Response Options
2.1. Were participants aware of their assigned intervention during the trial?	Patients are not informed regarding the randomization	No
2.2. Were carers and people delivering the intervention aware of participants' assigned intervention during the trial?	Surgeons will know which sutures they are using in each surgery	Yes
2.3. If Y/PY/NI to 2.2: Were there deviations from the intended intervention that arose because of the trial context?	There are no deviations from the intended intervention	No
2.4. If Y/PY to 2.3: Were these deviations likely to have affected the outcome?	Not assessed	
2.5. If Y/PY/NI to 2.4: Were these deviations from intended intervention balanced between groups?	Not assessed	
2.6. Was an appropriate analysis used to estimate the effect of assignment to intervention?	Patients with missing outcome are excluded	Yes
2.7 If N/PN/NI to 2.6: Was there potential for a substantial impact (on the result) of the failure to analyze participants in the group to which they were randomized?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Domain 3: Risk of Bias due to Missing Outcome Data

Signaling Questions	Comments	Response Options
3.1. Were data for this outcome available for all, or nearly all, participants randomized?	All participants' outcomes are available	Yes
3.2 If N/PN/NI to 3.1: Is there evidence that the result was not biased by missing outcome data?	Not assessed	
3.3. If N/PN to 3.2: Could missingness in the outcome depend on its true value?	Not assessed	
3.4. If Y/PY/NI to 3.3: Is it likely that missingness in the outcome depended on its true value?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Domain 4: Risk of Bias in Measurement of the Outcome

Signaling Questions	Comments	Response Options
4.1. Was the method of measuring the outcome inappropriate?	Outcomes are prespecified and measured with validated and calibrated assessment tools	No
4.2. Could measurement or ascertainment of the outcome have differed between intervention groups?	Both groups have the same measurement of outcomes	No
4.3. If N/PN/NI to 4.1 and 4.2: Were outcome assessors aware of the intervention received by study participants?	Not assessed	
4.4. If Y/PY/NI to 4.3: Could assessment of the outcome have been influenced by knowledge of intervention received?	Not assessed	
4.5. If Y/PY/NI to 4.4: Is it likely that assessment of the outcome was influenced by knowledge of intervention received?	Not assessed	
Risk-of-bias judgment	Low risk of bias	

- Domain 5: Risk of Bias in Selection of the Reported Result

Signaling Questions	Comments	Response Options
5.1 Were the data that produced this result analyzed in accordance with a prespecified analysis plan that was finalized before unblinded outcome data were available for analysis?	Researchers' prespecified intentions are available in sufficient detail	Yes
Is the numerical result being assessed likely to have been selected, on the basis of the results, from. . .		
5.2. . . . multiple eligible outcome measurements (eg, scales, definitions, time points) within the outcome domain?	Outcome measurements are not assessed using multiple instruments	No
5.3 . . . multiple eligible analyses of the data?	Outcome measurements are not analyzed in multiple ways.	No
Risk-of-bias judgment	Low risk of bias	

Overall risk of bias: low risk of bias.