TECHNOLOGY ASSISTED ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION IMPROVES TUNNEL PLACEMENT BUT LEADS TO NO CHANGE IN CLINICAL OUTCOMES: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ISAKOS 2023: Congress in Boston, USA

Disclosures

The authors declare that they have no conflicts of interest.

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Background and Purpose

Failure of primary anterior cruciate ligament reconstruction (ACLR) leads to revision surgeries which have higher cost burdens compared to the initial surgery. The most common technical cause of primary ACLR failure is non-anatomic tunnel placement.

The purpose of this study was to investigate the effect of technology assisted ACLR on post-operative clinical outcomes and tunnel placement compared to conventional arthroscopic ACLR.

Methods

CENTRAL, MEDLINE, and Embase were searched from January 2000 to November 2022. Articles were included if there was intraoperative use of computer-assisted navigation (CAN), robotics, diagnostic imaging, computer simulations, or 3D printing (3DP). Two reviewers searched, screened, and evaluated the included studies for data quality. Data was abstracted using descriptive statistics and pooled using relative risk ratios (RR) or mean differences (MD), both with 95% confidence intervals (CI), where appropriate.

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Results – Demographics and Study Characteristics

Demographics

- Eleven studies were included with total 775 patients and majority male participants (70.7%) (1 – 10). Ages ranged from 14 to 54 years (391 patients) and follow-up ranged from 12 to 60 months (775 patients).

Study Characteristics

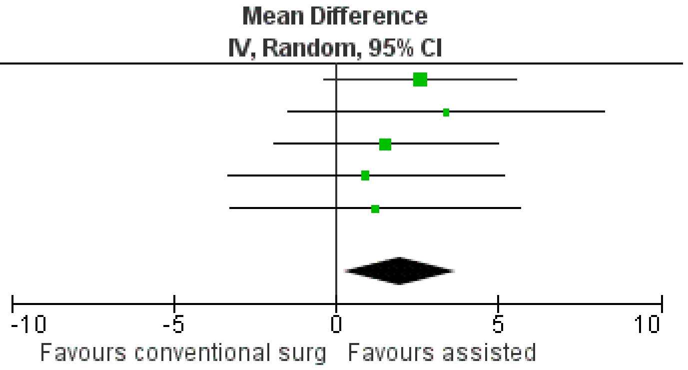
- Three studies used fluoroscopic CAN (160 patients), one used intraoperative fluoroscopy (60 patients), two used personalized 3D printed drill guides (119 patients), and five used image-free CAN (454 patients).

Results – Subjective Clinical Outcomes

Subjective IKDC

Study or Subgroup	Tech Assisted Mean	Tech Assisted SD	Tech Assisted Total	Conventional Surg Mean	Conventional Surg SD	Conventional Surg Total	Weight	Mean Difference IV, Random, 95% CI
Ahn 2019	92.3	5.2	30	89.7	6.4	30	33.0%	2.60 [-0.35, 5.55]
Hart 2008	76.5	10.3	40	73.1	11.8	40	12.2%	3.40 [-1.45, 8.25]
Liu 2020	87.23	5.6	22	85.68	5.58	19	24.4%	1.55 [-1.88, 4.98]
Margier 2015	81.7	14.8	114	80.8	16.6	100	16.0%	0.90 [-3.34, 5.14]
Zhu 2018	80.9	10.5	40	79.7	9.6	38	14.4%	1.20 [-3.26, 5.66]
Total (95% CI)			**246**			**227**	**100.0%**	**1.97 [0.27, 3.66]**

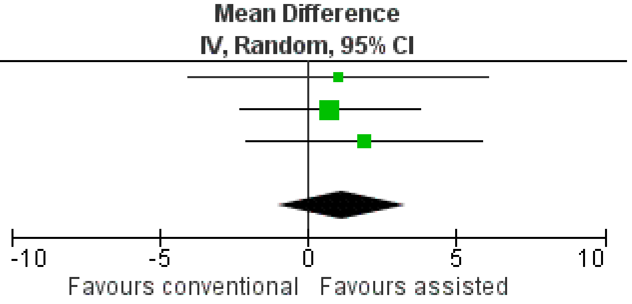
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.93$, df = 4 (P = 0.92); $I^2 = 0\%$
Test for overall effect: Z = 2.28 (P = 0.02)



Lysholm Score

Study or Subgroup	Tech Assisted Mean	Tech Assisted SD	Tech Assisted Total	Conventional Surg Mean	Conventional Surg SD	Conventional Surg Total	Weight	Mean Difference IV, Random, 95% CI
Hart 2008	88.9	12.1	40	87.9	11	40	18.3%	1.00 [-4.07, 6.07]
Liu 2020	82	4.39	22	81.26	5.31	19	51.8%	0.74 [-2.27, 3.75]
Zhu 2018	89.3	7.6	40	87.4	10	38	30.0%	1.90 [-2.06, 5.86]
Total (95% CI)			**102**			**97**	**100.0%**	**1.14 [-1.03, 3.30]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.21$, df = 2 (P = 0.90); $I^2 = 0\%$
Test for overall effect: Z = 1.03 (P = 0.30)



Subjective IKDC scores **increased** in the technology assisted surgery (TAS) group (473 patients; P = 0.02; MD 1.97, 95% CI 0.27 to 3.66). There was **no difference** in Lysholm scores (199 patients; MD 1.14, 95% CI - 1.03 to 3.30).

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Results – Subjective Clinical Outcomes

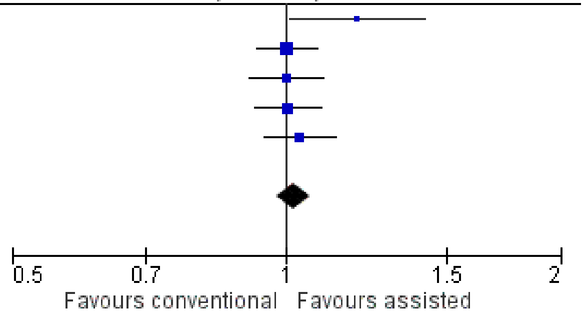
Objective IKDC

Study or Subgroup	Tech Assisted Events	Tech Assisted Total	Conventional Surg Events	Conventional Surg Total	Weight	Risk Ratio M-H, Random, 95% CI
Ahn 2019	30	30	25	30	6.4%	1.20 [1.01, 1.42]
Chouteau 2008	36	37	35	36	28.5%	1.00 [0.93, 1.08]
Endele 2009	20	20	20	20	19.7%	1.00 [0.91, 1.10]
Margier 2015	104	114	91	100	24.4%	1.00 [0.92, 1.09]
Plaweski 2006	30	30	29	30	20.9%	1.03 [0.94, 1.13]
Total (95% CI)		**231**		**216**	**100.0%**	**1.02 [0.98, 1.06]**
Total events	220		200			

Heterogeneity: Tau² = 0.00; Chi² = 4.31, df = 4 (P = 0.37); I² = 7%

Test for overall effect: Z = 0.87 (P = 0.38)

Risk Ratio M-H, Random, 95% CI



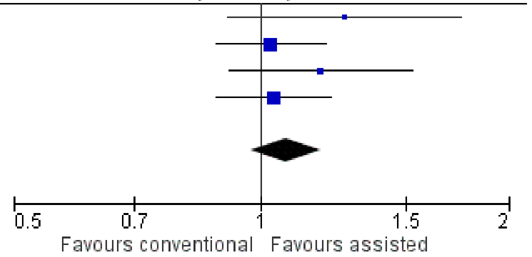
Negative Pivot Shift

Study or Subgroup	Tech Assisted Events	Tech Assisted Total	Conventional Surg Events	Conventional Surg Total	Weight	Risk Ratio M-H, Random, 95% CI
Ahn 2019	24	30	19	30	9.1%	1.26 [0.91, 1.75]
Hart 2008	36	40	35	40	39.4%	1.03 [0.88, 1.20]
Plaweski 2006	26	30	22	30	14.5%	1.18 [0.91, 1.53]
Zhu 2018	36	40	33	38	37.0%	1.04 [0.88, 1.22]
Total (95% CI)		**140**		**138**	**100.0%**	**1.07 [0.97, 1.18]**
Total events	122		109			

Heterogeneity: Tau² = 0.00; Chi² = 2.27, df = 3 (P = 0.52); I² = 0%

Test for overall effect: Z = 1.39 (P = 0.16)

Risk Ratio M-H, Random, 95% CI



There was **no difference** in objective IKDC scores (447 patients; RR 1.02, 95% CI 0.98 to 1.06) or negative pivot shift tests (278 patients; RR 1.07, 95% CI 0.97 to 1.18) between the two groups.

Results – Tunnel Placement Accuracy

When using TAS, six (351 patients) of eight (451 patients) studies reported more accurate femoral tunnel placement and six (321 patients) of ten (561 patients) studies reported more accurate tibial tunnel placement in at least one measure.

Results – Operating Time and Cost

Operating Time

- Four studies (342 patients) reported a significant increase in operating time when using CAN (mean 152.7 min, 109 min, 86.9 min, 78 min) versus conventional surgery (CS) (mean 119.7 min, 91 min, 59.1 min, 52 min). One 3DP study (41 patients) demonstrated a significant decrease in intraoperative positioning time of the tibial tunnel (mean 3.3 min in TAS vs 5.9 min in CS) and the other (78 patients) demonstrated no difference in operating time between the two groups.

Operative Cost

- One study (209 patients) demonstrated a significant increase in cost with use of CAN (mean 1158€) versus CS (mean 704€). Of the two studies using 3DP templates, production costs ranging from $10 to $42 USD were cited.

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Results – Adverse Events

There was no difference in adverse events between the two groups in studies that reported such data.

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Conclusion

Objective clinical outcomes do not differ between TAS and CS despite subjective outcomes improving. CAN is more expensive and time consuming while 3DP is inexpensive and does not lead to greater operating times. Despite improvements with TAS, tunnel placement data is difficult to interpret due to heterogeneity between methods of measurement which may affect clinical outcomes.

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ACKNOWLEDGEMENTS

A special thank you to Dr. Darren de SA, Dr. Dan Cohen, MacOrtho, and the MacSports team for their support.

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