Do new technologies help us to achieve the chosen alignment?

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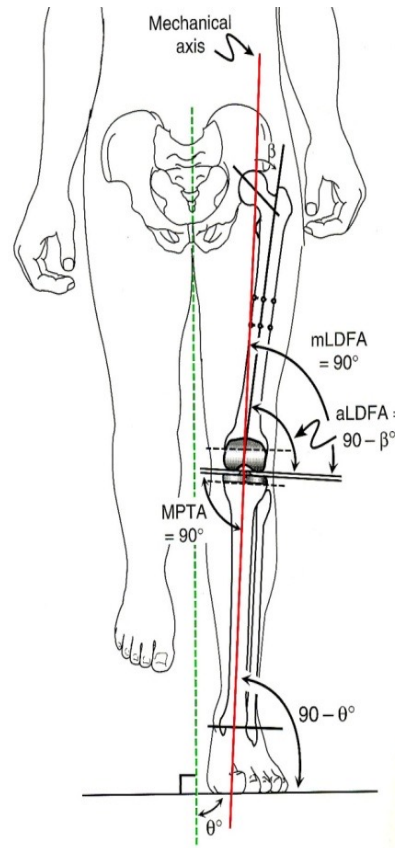
NEW TECHNOLOGIES

- **Navigation**
- **PSI**
- **Accelerometer**
- **Augmented reality**
- **Robotics**

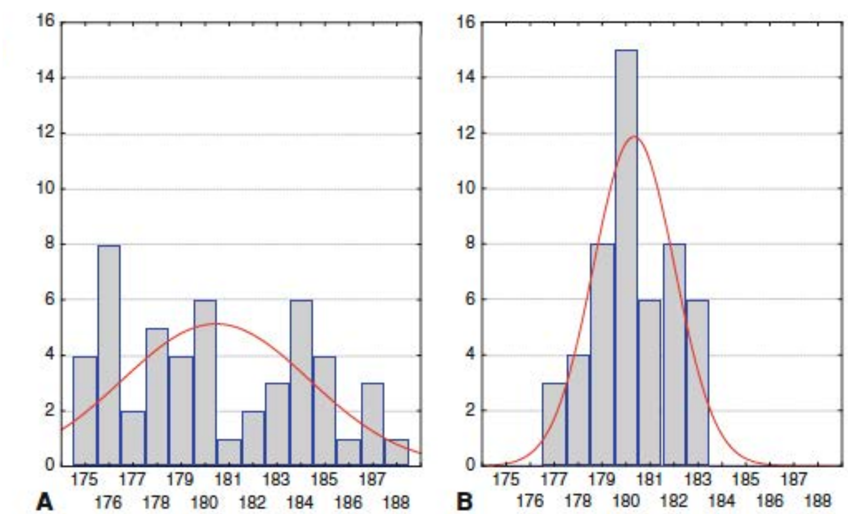
- **Other technologies**



NAVIGATION SYSTEMS (CAS)

Parc de Salut Barcelona MAR

- **Systems that allow a precise placement of instruments and implants in the surgical field**



NAVIGATION - LIMB ALIGNMENT

	CAS n/N	Conventional n/N
nRCT		
Anderson (2005)[24]	6/116	8/51
Bathis (2004b)[25]	2/50	12/50
Chang (2006)[27]	9/48	12/29
Confalonieri (2005)[30]	5/38	21/77
Daubresse (2005)[31]	0/50	14/50
Haaker (2005)[33]	21/100	72/100
Jenny (2005)[23]	18/235	65/235
Kim (2005)[35]	4/69	21/78
Matsumoto (2004)[36]	2/30	10/30
Perlick (2004a)[38]	3/40	11/40
Perlick (2004b)[39]	4/50	12/50
Skowronski (2005)[42]	24/100	44/100
Zorman (2005)[45]	0/71	19/64
Zumstein (2006)[46]	8/55	8/29
RCT		
Bathis (2004a)[14]	3/80	18/80
Bohling (2005)[26]	3/50	27/50
Chauhan (2004)[28]	5/34	10/30
Chin (2005)[29]	6/30	22/60
Oberst (2003)[37]	0/12	5/13
Saragaglia (2001)[40]	4/25	6/25
Sparmann (2003)[41]	0/120	16/120
Stulberg (2000)[43]	0/15	5/15
Meta-Analysis*	k = 22 N = 2,794	

n=knees malaligned
N=total knees studied
k= number of studies

*Heterogeneity chi² P = .0508
Test of OR=1 P < .00001

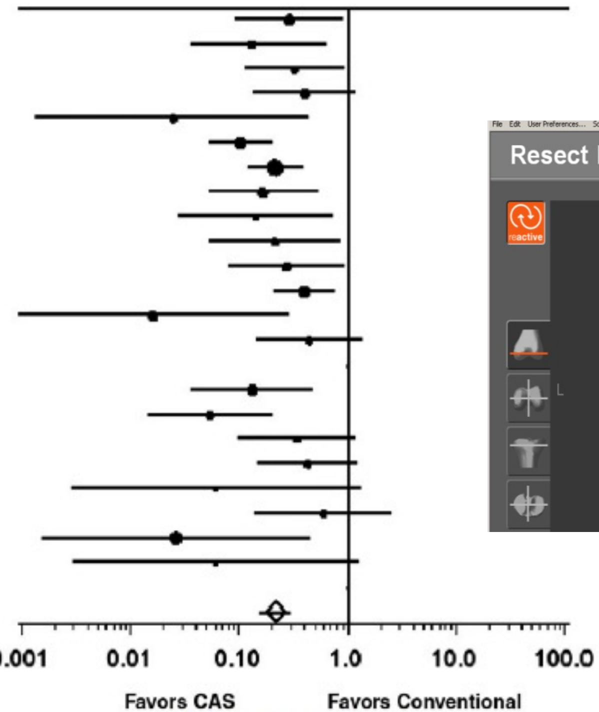
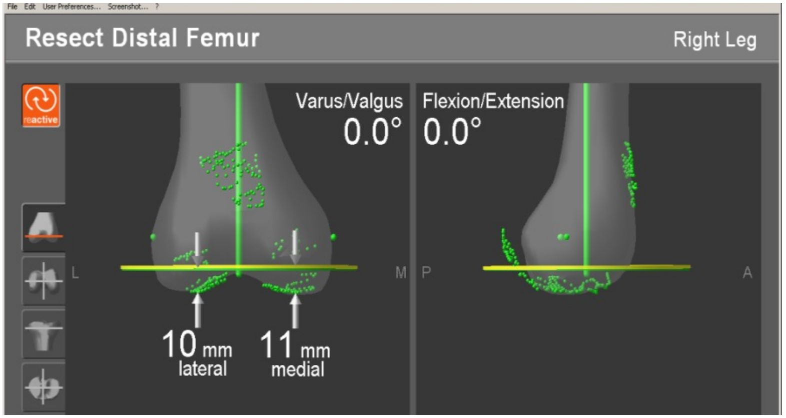


Fig. 1. Malalignment for mechanical axis greater than 3° [14,23-31,33,35-43,45,46].



Meta-Analysis of Alignment Outcomes in Computer-Assisted Total Knee Arthroplasty Surgery

J. Bohannon Mason, MD,* Thomas K. Fehring, MD,* Rhonda Estok, RN, BSN,† Deirdre Banel, BA, and Kyle Fahrbach, PhD†

The Journal of Arthroplasty Vol. 22 No. 8 2007

NAVIGATION - ALIGNMENT

Parc de Salut Barcelona MAR

Study or subgroup	Conventional TKA Events	Conventional TKA Total	CNTKA Events	CNTKA Total	Weight	Odds ratio (non-event) M-H, fixed, 95% CI
Barrett 2011	63	85	61	81	21.2%	1.07 [0.53, 2.15]
Choong 2009	33	54	50	57	5.8%	4.55 [1.74, 11.89]
Ensini 2006	45	60	53	60	7.3%	2.52 [0.95, 6.73]
Hiscox 2011	40	59	51	72	17.9%	1.15 [0.55, 2.43]
Lee 2010	40	56	55	60	4.8%	4.40 [1.49, 13.00]
Lutzner 2008	33	40	35	40	5.8%	1.48 [0.43, 5.14]
Macule-Beneyto 2006	25	84	49	102	19.9%	2.18 [1.19, 4.01]
Martin 2010	36	54	41	54	12.1%	1.58 [0.68, 3.66]
Matziolis 2007	21	28	31	32	1.0%	10.33 [1.18, 90.26]
Mombert 2007	17	21	21	21	0.6%	11.06 [0.56, 219.68]
Seon 2009	33	42	41	43	2.2%	5.59 [1.13, 27.67]
Zhang 2011	23	32	32	32	0.5%	26.28 [1.46, 474.18]
Zhang 2012	33	41	39	40	1.1%	9.45 [1.12, 79.55]
Total (95% CI)		**656**		**694**	**100.0%**	**2.32 [1.77, 3.04]**
Total events	442		559			

Heterogeneity: Chi-squared = 21.12, df = 12 ($P = 0.05$); $I^2 = 43\%$

Test for overall effect: $Z = 6.13$ ($P < 0.00001$)

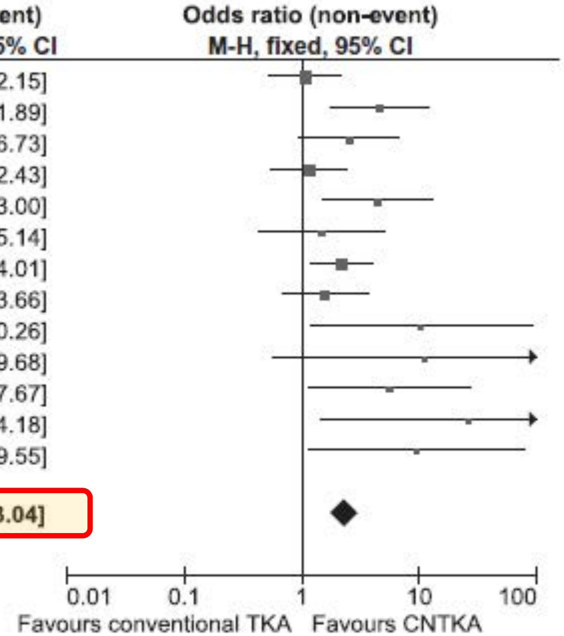


Fig. 1. Meta-analysis of satisfactory post-operative alignment of the mechanical axis in the frontal plane (post-operative deviation of ≤3° from target angle of 180°) in randomized control trials comparing conventional total knee arthroplasty (TKA) and computer-navigated total knee arthroplasty (CNTKA). CI, confidence interval; df, degrees of freedom.

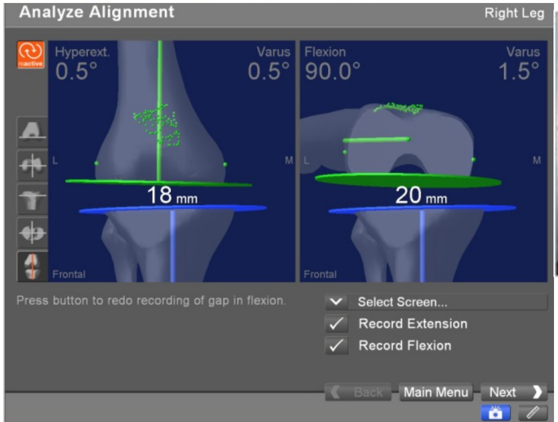
REVIEW ARTICLE

ANZJSurg.com

Systematic review of computer-navigated total knee arthroplasty

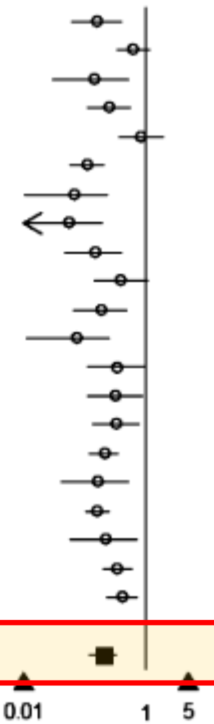
Luis A. Zamora, Karen J. Humphreys, Amber M. Watt, Deanne Forel and Alun L. Cameron

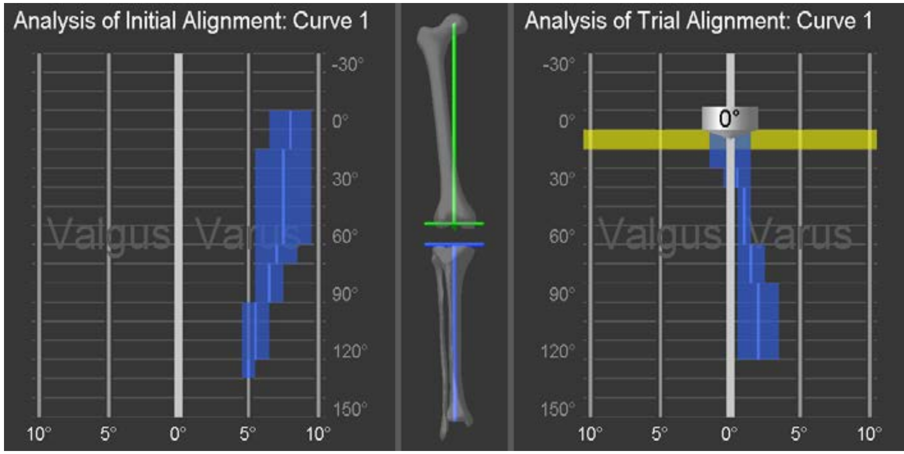
Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP-S), Royal Australasian College of Surgeons, Adelaide, South Australia, Australia



NAVIGATION - ALIGNMENT

Trial	Conventional TKA n/N	CAOS TKA n/N	Odds Ratio (95% CrI)
Rosenberger et al. (2008)	21/50	5/50	0.16 (0.06 to 0.39)
Kim et al. (2007)	35/100	28/100	0.63 (0.35 to 1.12)
Matziolis et al. (2007)	7/28	1/32	0.15 (0.03 to 0.51)
Martin et al. (2007)	24/100	8/100	0.26 (0.11 to 0.54)
Yau et al. (2008)	13/52	15/52	0.83 (0.37 to 1.96)
Haaker et al. (2005)	72/100	21/100	0.11 (0.06 to 0.20)
Daubresse et al. (2005)	16/50	0/50	0.07 (0.01 to 0.23)
Zorman et al. (2005)	19/62	0/72	0.06 (0.01 to 0.19)
Bahtis et al. (2004)	18/80	3/80	0.15 (0.05 to 0.39)
Decking et al. (2005)	16/25	13/27	0.39 (0.15 to 1.05)
Kim et al. (2005)	19/78	4/69	0.19 (0.07 to 0.47)
Sparmann et al. (2003)	16/120	0/120	0.07 (0.01 to 0.25)
Jenny et al. (2001)	9/30	5/30	0.34 (0.12 to 0.99)
Chauhan et al. (2004)	10/35	5/35	0.32 (0.11 to 0.89)
Ensini et al. (2006)	15/60	7/60	0.33 (0.13 to 0.78)
Jenny et al. (2005)	65/235	18/235	0.21 (0.12 to 0.36)
Matsumoto et al. (2004)	10/30	2/30	0.17 (0.04 to 0.51)
Tingart et al. (2008)	128/500	26/500	0.16 (0.10 to 0.24)
Oberst et al. (2008)	7/35	2/34	0.22 (0.06 to 0.73)
Mullaji et al. (2007)	40/185	26/282	0.35 (0.21 to 0.58)
Beneyto et al. (2006)	59/84	53/102	0.41 (0.23 to 0.74)
Total	619/2039	242/2160	0.21 (0.12 to 0.33)





Imageless computer assisted versus conventional total knee replacement. A Bayesian meta-analysis of 23 comparative studies

Yaron S. Brin · Vassilios S. Nikolaou ·
Lawrence Joseph · David J. Zukor · John Antoniou

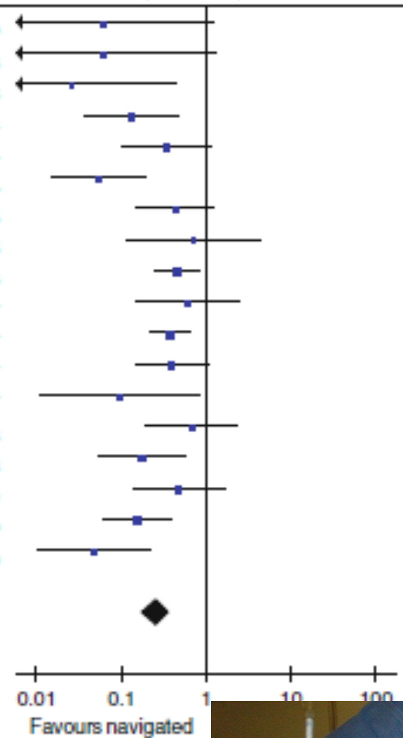
International Orthopaedics (SICOT) (2011) 35:331–339

NAVIGATION - LIMB ALIGNMENT

Study or Subgroup	navigated Events	navigated Total	conventional Events	conventional Total	Weight	Odds Ratio M-H, Random, 95% CI	Year
Stulberg2000	0	15	5	15	1.5%	0.06 [0.00, 1.24]	2000
Oberst2003	0	12	5	13	1.5%	0.06 [0.00, 1.27]	2003
Sparmann2003	0	120	16	120	1.7%	0.03 [0.00, 0.44]	2003
Bathis2004	3	80	18	80	5.7%	0.13 [0.04, 0.48]	2004
Chauhan2004	5	34	10	30	6.0%	0.34 [0.10, 1.16]	2004
Bohling2005	3	50	27	50	5.5%	0.05 [0.01, 0.20]	2005
Chin2005	6	30	22	60	7.1%	0.43 [0.15, 1.22]	2005
Seon 2006	2	49	3	53	3.4%	0.71 [0.11, 4.43]	2006
Beneyto2006	53	102	59	84	10.7%	0.46 [0.25, 0.84]	2006
Saragaglia2001	4	25	6	25	5.0%	0.60 [0.15, 2.47]	2007
Mullaji2007	26	282	40	185	11.4%	0.37 [0.22, 0.63]	2007
Ensini2007	7	60	15	60	7.5%	0.40 [0.15, 1.06]	2007
Matziolis2007	1	32	7	28	2.6%	0.10 [0.01, 0.85]	2007
Lützner2008	5	40	7	40	5.8%	0.67 [0.19, 2.33]	2008
Dutton2008	4	52	18	56	6.3%	0.18 [0.05, 0.56]	2008
Strien2009	7	36	7	21	5.9%	0.48 [0.14, 1.65]	2009
Hsu2010	8	60	30	60	8.1%	0.15 [0.06, 0.38]	2010
Hernández2010	2	40	21	40	4.3%	0.05 [0.01, 0.22]	2010
Total (95% CI)		**1119**		**1020**	**100.0%**	**0.26 [0.17, 0.38]**	
Total events	136		316				

Heterogeneity: Tau² = 0.27; Chi² = 30.70, df = 17 (P = 0.02); I² = 45%

Test for overall effect: Z = 6.93 (P < 0.00001)

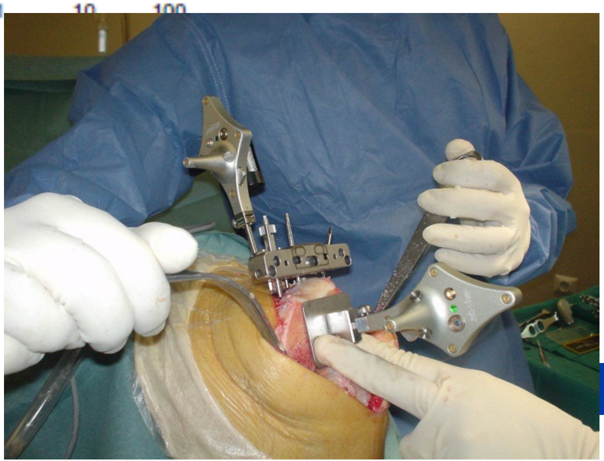


Knee Surg Sports Traumatol Arthrosc (2012) 20:1075–1082
DOI 10.1007/s00167-011-1695-6

KNEE

Alignment outcomes in navigated total knee arthroplasty: a meta-analysis

Yonghui Fu · Mingming Wang · Yifeng Liu · Qin Fu



NAVIGATION - COMPONENTS ALIGNMENT

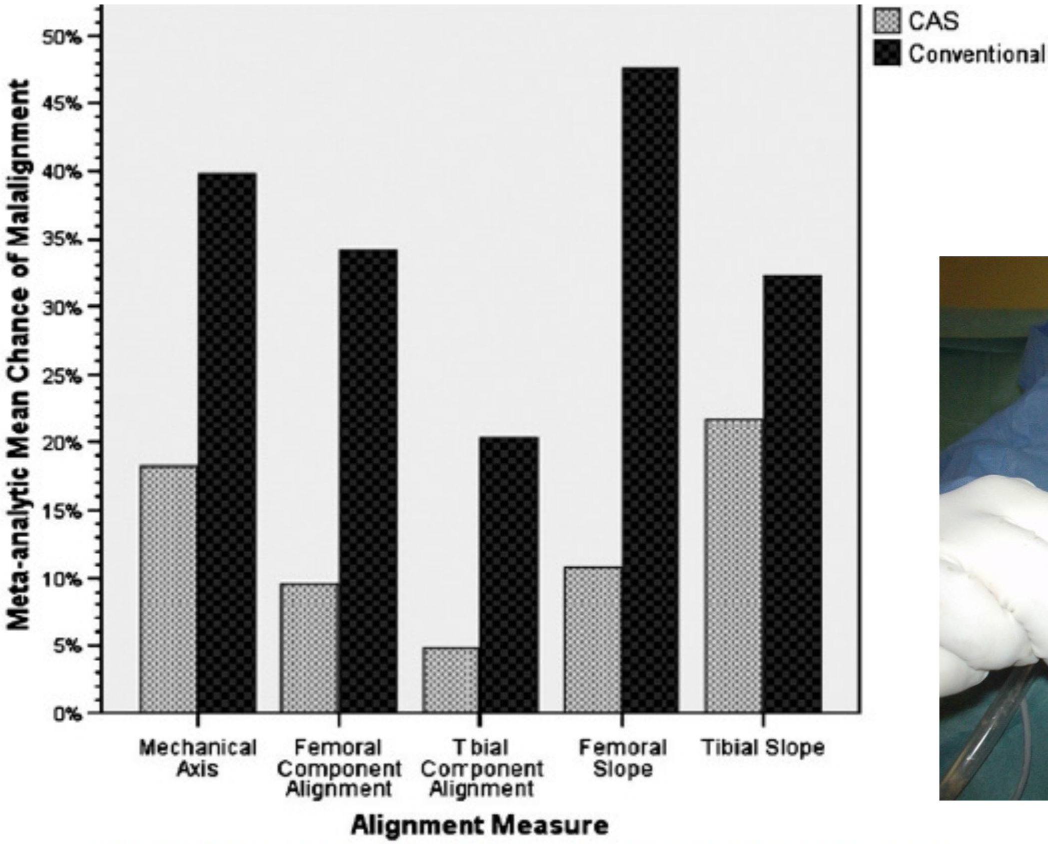
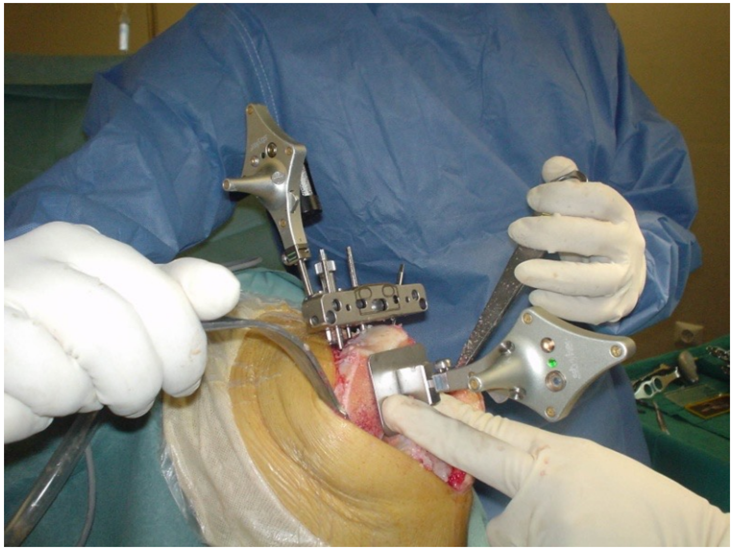


Fig. 4. Meta-analytic mean chance of malalignment at great



Meta-Analysis of Alignment Outcomes in Computer-Assisted Total Knee Arthroplasty Surgery

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Deirdre Banel, BA, and Kyle Fahrbach, PhD†

Knee Surg Sports Traumatol Arthrosc (2012) 20:1307–1322
DOI 10.1007/s00167-011-1588-8

KNEE

Does computer-assisted surgery improve postoperative leg alignment and implant positioning following total knee arthroplasty? A meta-analysis of randomized controlled trials?

Tao Cheng · Song Zhao · Xiaochun Peng ·
Xianlong Zhang

NAVIGATION - COMPONENTS ALIGNMENT

Parc de Salut Barcelona MAR

Trial	Conventional TKA n/N	CAOS TKA n/N	Odds Ratio (95% CrI)
Rosenberger et al. (2008)	6/50	1/50	0.15 (0.02 to 0.69)
Kim et al. (2007)	9/100	13/100	1.16 (0.48 to 2.85)
Matziolis et al. (2007)	3/28	0/32	0.10 (0.01 to 0.66)
Martin et al. (2007)	14/100	5/100	0.28 (0.10 to 0.75)
Bolognesi et al. (2005)	5/50	1/50	0.17 (0.02 to 0.82)
Yau et al. (2008)	3/52	3/52	0.56 (0.12 to 2.56)
Daubresse et al. (2005)	13/50	5/50	0.28 (0.09 to 0.76)
Zorman et al. (2005)	12/62	0/72	0.05 (0.00 to 0.23)
Bahtis et al. (2004)	11/80	6/80	0.42 (0.15 to 1.12)
Decking et al. (2005)	5/25	5/27	0.60 (0.17 to 2.21)
Sparmann et al. (2003)	34/120	1/120	0.04 (0.01 to 0.14)
Jenny et al. (2001)	5/30	2/30	0.27 (0.05 to 1.12)
Chauhan et al. (2004)	3/35	0/35	0.11 (0.01 to 0.70)
Ensini et al. (2006)	9/60	0/60	0.06 (0.00 to 0.32)
Jenny et al. (2005)	54/235	26/235	0.40 (0.24 to 0.65)
Matsumoto et al. (2004)	9/30	2/30	0.16 (0.03 to 0.60)
Tingart et al. (2008)	159/500	20/500	0.09 (0.05 to 0.14)
Total	354/1607	90/1623	0.19 (0.08 to 0.39)

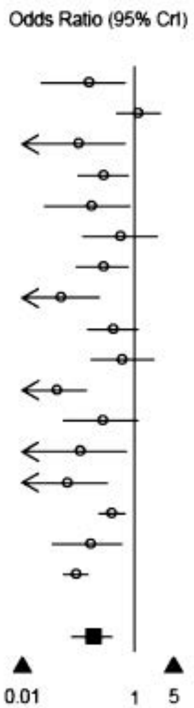


Fig. 3 Femoral angle diagram for prospective randomised and retrospective studies

Trial	Conventional TKA n/N	CAOS TKA n/N	Odds Ratio (95% CrI)
Rosenberger et al. (2008)	10/50	2/50	0.16 (0.03 to 0.56)
Kim et al. (2007)	7/100	16/100	1.85 (0.77 to 4.84)
Matziolis et al. (2007)	5/28	0/32	0.08 (0.00 to 0.46)
Martin et al. (2007)	15/100	3/100	0.17 (0.05 to 0.49)
Bolognesi et al. (2005)	4/50	0/50	0.09 (0.01 to 0.59)
Yau et al. (2008)	5/52	7/52	0.98 (0.31 to 3.20)
Daubresse et al. (2005)	10/50	0/50	0.06 (0.00 to 0.29)
Zorman et al. (2005)	7/62	0/72	0.06 (0.00 to 0.35)
Bahtis et al. (2004)	5/80	2/80	0.29 (0.06 to 1.19)
Decking et al. (2005)	5/25	1/27	0.16 (0.02 to 0.74)
Sparmann et al. (2003)	12/120	1/120	0.10 (0.01 to 0.37)
Jenny et al. (2001)	6/30	2/30	0.24 (0.05 to 0.95)
Chauhan et al. (2004)	3/35	0/35	0.10 (0.01 to 0.74)
Ensini et al. (2006)	2/60	1/60	0.29 (0.03 to 1.88)
Jenny et al. (2005)	41/235	26/235	0.56 (0.33 to 0.94)
Matsumoto et al. (2004)	7/30	2/30	0.21 (0.04 to 0.80)
Tingart et al. (2008)	105/500	23/500	0.18 (0.11 to 0.28)
Total	249/1607	86/1623	0.19 (0.07 to 0.41)

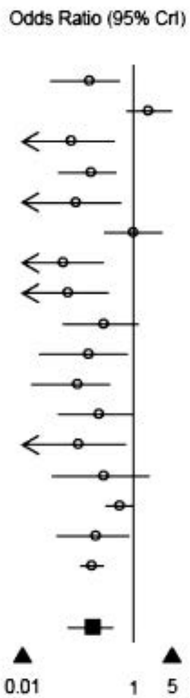


Fig. 4 Tibial angle diagram for prospective randomised and retrospective studies

Imageless computer assisted versus conventional total knee replacement. A Bayesian meta-analysis of 23 comparative studies

Yaron S. Brin · Vassilios S. Nikolaou · Lawrence Joseph · David J. Zukor · John Antoniou

International Orthopaedics (SICOT) (2011) 35:331–339

NAVIGATION - ROTATIONAL ALIGNMENT

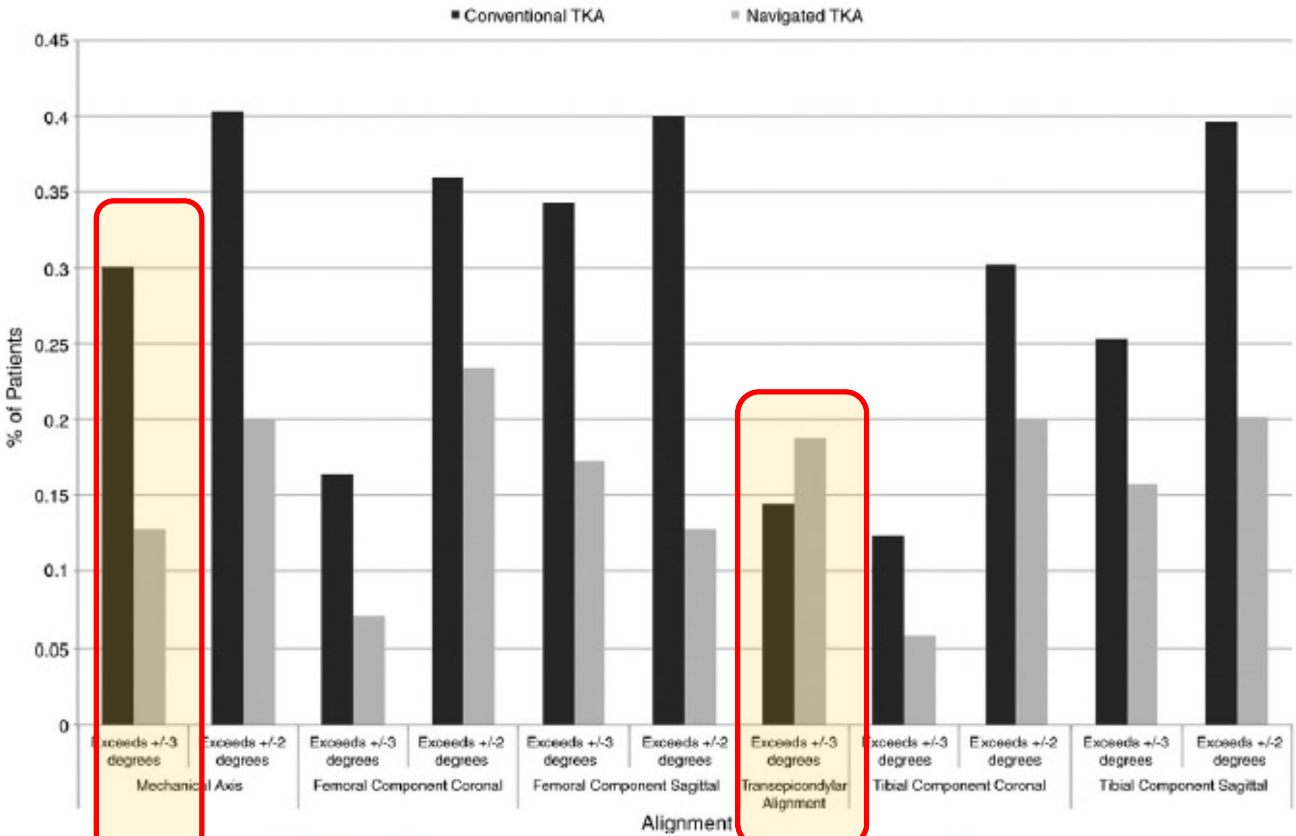
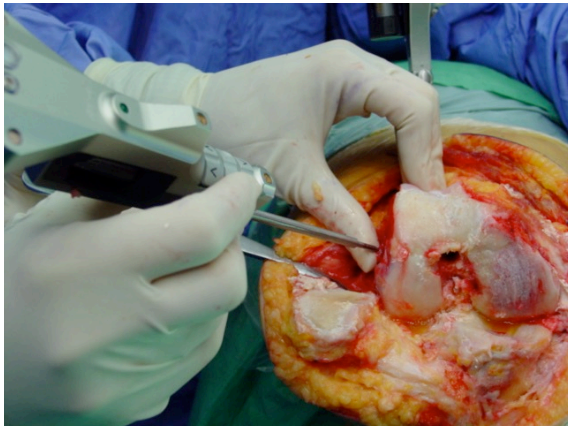
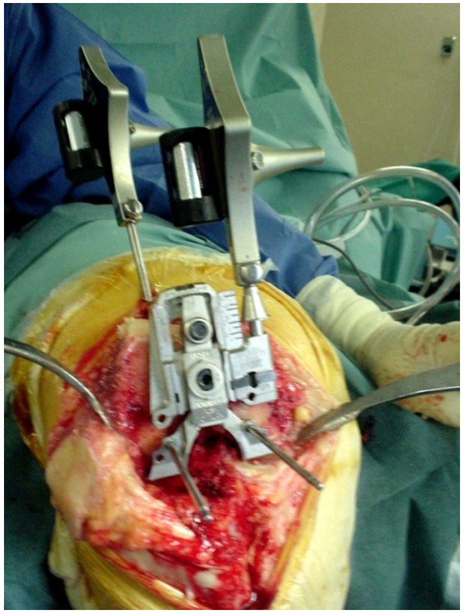


Fig. 3. Alignment outcomes in navigated vs conventional TKA.

The Journal of Arthroplasty Vol. 27 No. 6 2012

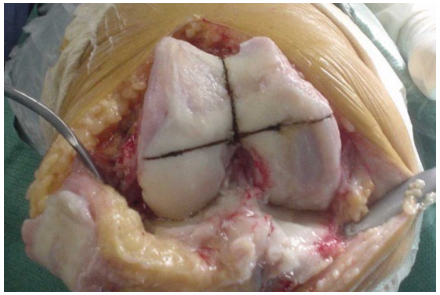


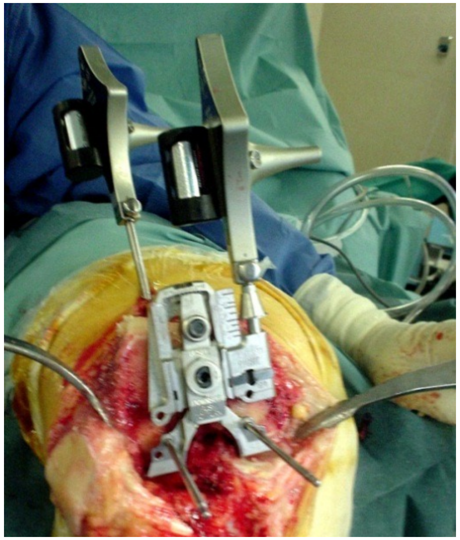


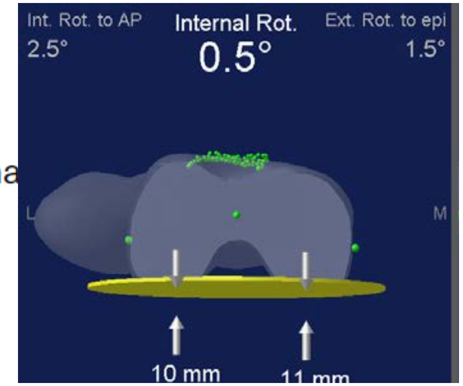
Meta-Analysis of Navigation vs Conventional Total Knee Arthroplasty

Bandar M. Hetaimish, MD,* M. Moin Khan, BHSc, MD,* Nicole Simunovic, MSc,†
Hatem H. Al-Harbi, MBChB, FRCSC,‡ Mohit Bhandari, MD, PhD, FRCSC,*
and Paul K. Zalzal, MASc, MD, FRCSC*

Outliers	Number of Studies	Navigation Knee(n/N)	Conventional Knee(n/N)	RR	95%CI	*P*-value	HG
Lower limb axis							
Mal-alignment −2,+2							
Full-length radiograph	16	252/1225	469/1093	0.54	0.44,0.67	$P < 0.00001$	57%
Computed tomography	3	26/106	39/98	0.62	0.35,1.09	$P = 0.10$	43%
Mal-alignment −3,+3							
Full-length radiograph	31	299/2709	698/2554	0.40	0.31,0.51	$P < 0.00001$	68%
Computed tomography	7	32/374	77/368	0.38	0.21,0.68	$P = 0.001$	41%
Femoral component coronal alignment							
Mal-alignment −2,+2							
Full-length radiograph	11	62/596	151/545	0.45	0.26,0.78	$P = 0.004$	65%
Computed tomography	2	8/67	13/63	0.59	0.21,1.62	$P = 0.30$	28%
Mal-alignment −3,+3							
Full-length radiograph	19	101/1694	342/1629	0.37	0.22,0.64	$P = 0.0003$	74%
Computed tomography	3	15/227	30/223	0.54	0.28,1.02	$P = 0.06$	2%
Tibial component coronal alignment							
Mal-alignment −2,+2							
Full-length radiograph	9	21/529	103/482	0.25	0.13,0.49	$P < 0.0001$	37%
Computed tomography	2	8/67	15/63	0.53	0.24,1.14	$P = 0.10$	1%
Mal-alignment −3,+3							
Full-length radiograph	19	77/1694	226/1629	0.41	0.25,0.66	$P = 0.0002$	51%
Computed tomography	3	8/227	23/223	0.37	0.13,1.01	$P = 0.05$	12%
Femoral component sagittal alignment							
Mal-alignment −2,+2							
Full-length radiograph	6	44/345	130/321	0.34	0.20,0.58	$P < 0.0001$	61%
Computed tomography	1	9/35	10/35	0.90	0.42,1.94	$P = 0.79$	NA
Mal-alignment −3,+3							
Full-length radiograph	11	150/786	276/743	0.50	0.37,0.67	$P < 0.00001$	63%
Computed tomography	1	4/35	6/35	0.67	0.21,2.16	$P = 0.50$	NA
Tibial slope							
Mal-alignment −2,+2							
Full-length radiograph	5	57/272	105/235	0.41	0.18, 0.90	$P = 0.03$	85%
Computed tomography	2	6/104	43/104	0.14	0.06 0.32	$P < 0.00001$	0%
Mal-alignment −3,+3							
Full-length radiograph	14	133/1023	202/961	0.64	0.43 0.96	$P = 0.03$	70%
Computed tomography	3	25/227	56/223	0.43	0.19 0.98	$P = 0.05$	63%
Femoral rotation							
Mal-alignment −2,+2	4	26/123	48/125	0.55	0.25,1.22	$P = 0.14$	69%
Mal-alignment −3,+3	6	62/383	57/385	0.96	0.50, 1.86	$P = 0.91$	62%
Tibial rotation							
Mal-alignment −3,+3	3	96/294	98/294	1.01	0.81,1.25	$P = 0.95$	0%





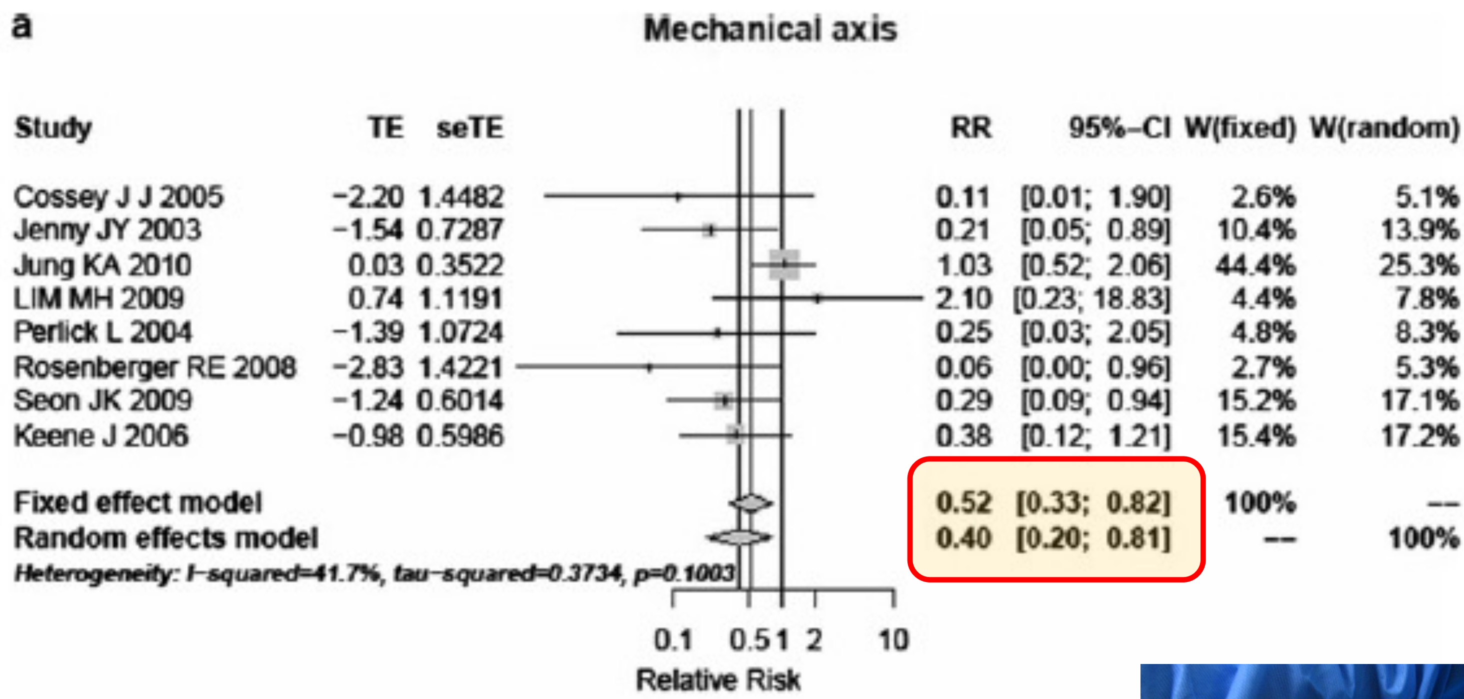


Imageless Navigation System Does Not Improve Component Rotational Alignment in Total Knee Arthroplasty

Tao Cheng, M.D., Ph.D.,*[,2] Guoyou Zhang, M.D., Ph.D.,†‡[2] and Xianlong Zhang, M.D., Ph.D.*[,1]

Journal of Surgical Research 171, 590–600 (2011)

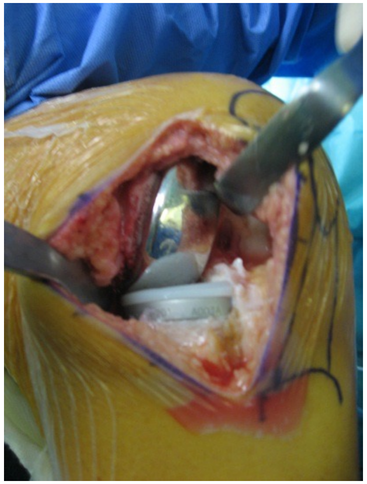
NAVIGATION - UKA ALIGNMENT



Improved accuracy in computer-assisted unicondylar knee arthroplasty: a meta-analysis

Patrick Weber · Alexander Crispin · Florian Schmidutz ·
Sandra Utzschneider · Matthias F. Pietschmann ·
Volkmar Jansson · Peter E. Müller

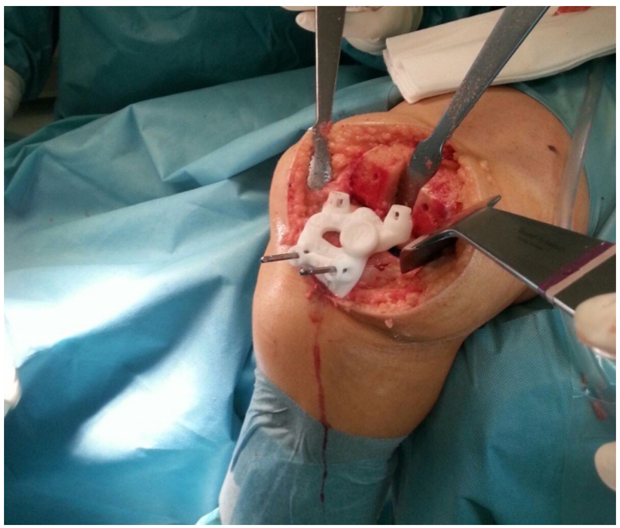
Knee Surg Sports Traumatol Arthrosc (2013) 21:2453–2461



PSI

-No improvement in components alignment

-No improvement in limb alignment (outliers)



THE BONE & JOINT JOURNAL

■ KNEE

A systematic review and meta-analysis of patient-specific instrumentation for improving alignment of the components in total knee replacement

E. Thienpont,
P. E. Schwab,
P. Fennema

From University Hospital Saint Luc-UCL, Brussels,

We conducted a meta-analysis, including randomised controlled trials (RCTs) and cohort studies, to examine the effect of patient-specific instruments (PSI) on radiological outcomes after total knee replacement (TKR) including: mechanical axis alignment and malalignment of the femoral and tibial components in the coronal, sagittal and axial planes, at a threshold of > 3° from neutral. Relative risks (RR) for malalignment were determined for all studies and for RCTs and cohort studies separately.

Of 325 studies initially identified, 16 met the eligibility criteria, including eight RCTs and eight cohort studies. There was no significant difference in the likelihood of mechanical axis malalignment with PSI *versus* conventional TKR across all studies (RR = 0.84, p = 0.304), in the RCTs (RR = 1.14, p = 0.445) or in the cohort studies (RR = 0.70, p = 0.289). The results for the alignment of the tibial component were significantly worse using PSI TKR than conventional TKR in the coronal and sagittal planes (RR = 1.75, p = 0.028; and RR = 1.34, p = 0.019, respectively, on pooled analysis). PSI TKR showed a significant advantage over conventional TKR for alignment of the femoral component in the coronal plane (RR = 0.65, p = 0.028 on pooled analysis), but not in the sagittal plane (RR = 1.12, p = 0.437). Axial alignment of the tibial (p = 0.460) and femoral components (p = 0.127) was not significantly different.

We conclude that PSI does not improve the accuracy of alignment of the components in TKR compared with conventional instrumentation.

Clinical O
and Relate

Clin Orthop Relat Res (2015) 473:151–158
DOI 10.1007/s11999-014-3804-6

SYMPOSIUM: 2014 KNEE SOCIETY PROCEEDINGS

Systematic Review of Patient-specific Instrumentation in Total Knee Arthroplasty: New but Not Improved

Adam Sassoon MD, Denis Nam MD,
Ryan Nunley MD, Robert Barrack MD

PSI

MRI-based PSI seem to be more precise

Study or Subgroup	CT Events	CT Total	MRI Events	MRI Total	Weight	Odds Ratio M-H, Random, 95% CI
Asada2014	5	20	4	20	21.6%	1.33 [0.30, 5.93]
Cenni 2014	3	23	3	21	17.1%	0.90 [0.16, 5.04]
Ensini 2014	9	23	4	22	24.6%	2.89 [0.74, 11.38]
Fritschy 2011	0	10	0	10		Not estimable
Frye 2015	9	23	2	27	18.1%	8.04 [1.52, 42.52]
Pfitzner 2014	9	30	2	30	18.7%	6.00 [1.17, 30.72]
Silva 2014	0	0	0	0		Not estimable
Total (95% CI)		**129**		**130**	**100.0%**	**2.76 [1.26, 6.05]**
Total events	35		15			

Heterogeneity: $Tau^2 = 0.16$; $Chi^2 = 5.01$, df = 4 (P = 0.29); $I^2 = 20\%$
Test for overall effect: Z = 2.54 (P = 0.01)

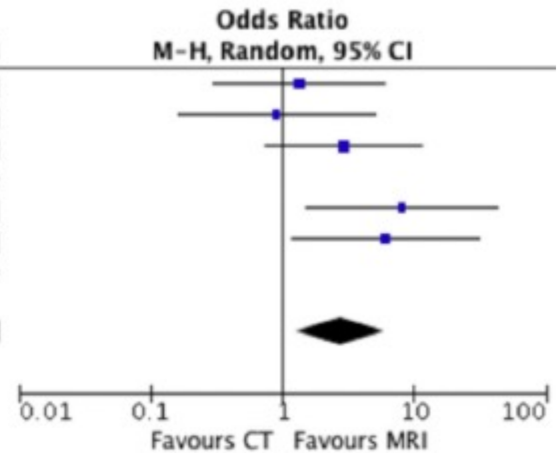
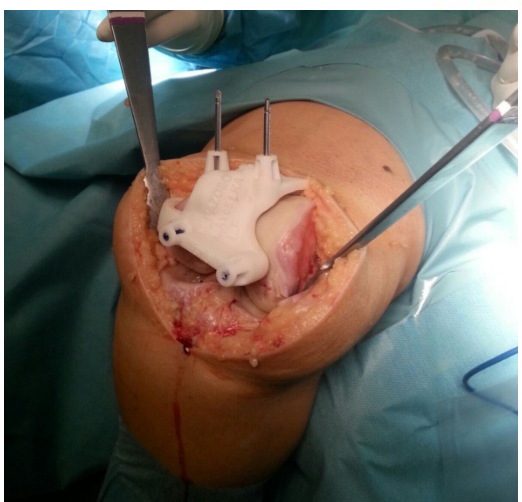


Fig. 2. Results of meta-analysis of mechanical axis outliers produced by MRI or CT-based PSI cutting guides.



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Original Article

Accuracy of MRI-based vs. CT-based patient-specific instrumentation in total knee arthroplasty: A meta-analysis

Vincent V.G. An [a,*], Brahman S. Sivakumar [b], Kevin Phan [a], Yadin David Levy [b], Warwick J.M. Bruce [a,b]

[a] Faculty of Medicine, University of Sydney, Camperdown, NSW, Australia
[b] Department of Orthopaedics, Concord Repatriation General Hospital, Concord, NSW, Australia

PSI

No clear improvement in TKA alignment

Table 1. Accuracy in the coronal plane: conventional instrumentation (CI) versus patient-specific instrumentation (PSI). CAS: computer-assisted surgery. CT: computed tomography. MRI: magnetic resonance imaging. LLR: full-leg standing radiographs. Signature® Biomet, Inc., Warsaw, IN, USA. Zimmer® Patient Specific Instrumentation (PSI), Zimmer, Warsaw, IN, USA. TruMatch® DePuy Orthopaedics, Warsaw, IN, USA. Visionaire Smith & Nephew, Memphis, TN, USA. Stryker, Mahwah, NJ, USA. Imprint® Aesculap, Tuttlingen, Germany. SD: standard deviation. n.s: not significant. * intention-to-treat. ** CAS.

		Valid cases				Percentage of outliers > 3º (%)		
	Initial n (CI/PSI)	CI	PSI	Imaging techniques	PSI system	CI	PSI	p value
Boonen et al., [61]	180 (90/90)	82	86	MRI	Signature	18	30	n.s
Chareancholvanich et al., [63]	80 (40/40)	40	40	MRI	Zimmer PSI	7.5	2.5	n.s
Hamilton et al., [64]	52 (26/26)	26	26	CT	Trumatch	31	35	n.s
Parratte et al., [65]	40 (20/20)	20	20	MRI	Zimmer PSI	10	20	n.s
Roh et al., [66]	100 (50/50)	48	42	CT	Signature	10	12	n.s
Kotela A. and Kotela I., [68]	112 (60/52)	46	49	CT	Signature	30	49	n.s
Victor et al., [71]	128 (64/64)	64	61	MRI	Signature	28	25	n.s
				CT	Trumatch			
				MRI + LLR	Visionaire			
				MRI	Zimmer PSI			
Woolson et al., [72]	60 (30/30)	26	22*	CT	Trumatch	38	41	n.s
Abane et al., [73]	140 (70/70)	67	59	MRI + LLR	Visionaire	32	33	n.s
Gan et al., [74]	70 (35/35)	35	35	CT	Stryker	23	3	< 0.001
Yan et al., [75]	90 (30/30/30**)	30	30	MRI	Zimmer PSI	43	27	n.s
Huijbregts et al., [76]	140 (65/75)	64	69	MRI + LLR	Visionaire	22	13	n.s
Vide et al., [78]	100 (50/50)	48	47	MRI + LLR	Visionaire	35	13	0.011
Maus et al., [80]	157 (78/79)	66	59	MRI	Imprint	12	26	0.04
Van Leeuwen et al., [81]	94 (50/44)	49	42	MRI	Signature	22	26	n.s

EXPERT REVIEW OF MEDICAL DEVICES
2019, VOL. 16, NO. 7, 555–567
https://doi.org/10.1080/17434440.2019.1627197

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REVIEW

Check for updates

Patient-specific instrumentation in total knee arthroplasty

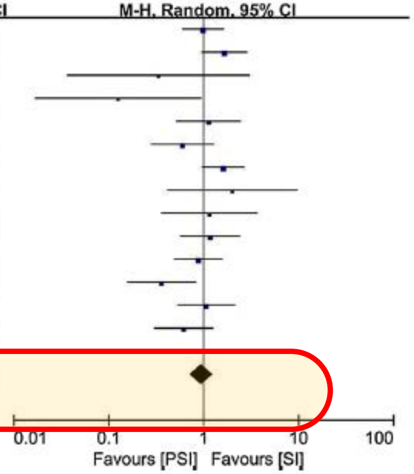
Vicente J. León-Muñoz[a], Francisco Martínez-Martínez[a,b], Mirian López-López[c] and Fernando Santonja-Medina[a,b]

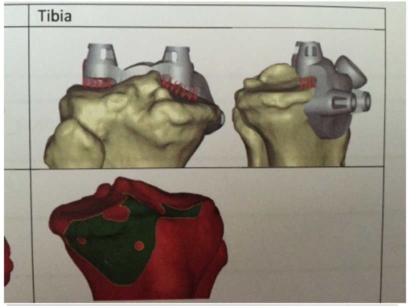
PSI

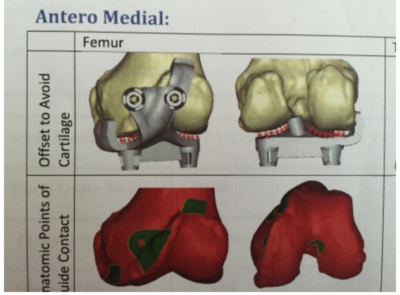
No clear improvement in TKA alignment

Study or Subgroup	PSI Events	PSI Total	SI Events	SI Total	Weight	Risk Ratio M-H, Random, 95% CI
Abane 2015	19	59	22	67	11.6%	0.98 [0.59, 1.62]
Boonen 2013	26	86	15	82	10.6%	1.65 [0.95, 2.89]
Chareancholvanich 2013	1	40	3	40	1.4%	0.33 [0.04, 3.07]
Gan 2015	1	35	8	35	1.7%	0.13 [0.02, 0.95]
Hamilton 2013	9	26	8	26	7.4%	1.13 [0.51, 2.46]
Huijbregts 2016	9	69	14	64	7.6%	0.60 [0.28, 1.28]
Kotela 2014	24	49	14	46	11.3%	1.61 [0.95, 2.71]
Parratte 2013	4	20	2	20	2.6%	2.00 [0.41, 9.71]
Roh 2013	5	42	5	48	4.2%	1.14 [0.36, 3.68]
Van 2017	11	42	11	49	8.1%	1.17 [0.56, 2.41]
Victor 2014	15	61	18	64	10.1%	0.87 [0.49, 1.58]
Vide 2017	6	47	17	48	6.8%	0.36 [0.16, 0.83]
Woolson 2014	9	22	10	26	8.5%	1.06 [0.53, 2.14]
Yan 2015	8	30	13	30	8.2%	0.62 [0.30, 1.27]
Total (95% CI)		**628**		**645**	**100.0%**	**0.94 [0.72, 1.24]**
Total events	147		160			

Heterogeneity: Tau² = 0.10; Chi² = 22.00, df = 13 (P = 0.06); I² = 41%
Test for overall effect: Z = 0.41 (P = 0.68)







Knee Surgery, Sports Trau
https://doi.org/10.1007/s00167-018-5256-0

KNEE

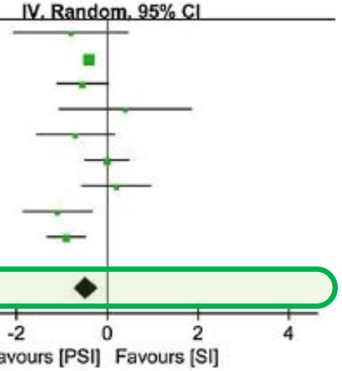
Patient-specific instrumentation improved axial alignment of the femoral component, operative time and perioperative blood loss after total knee arthroplasty

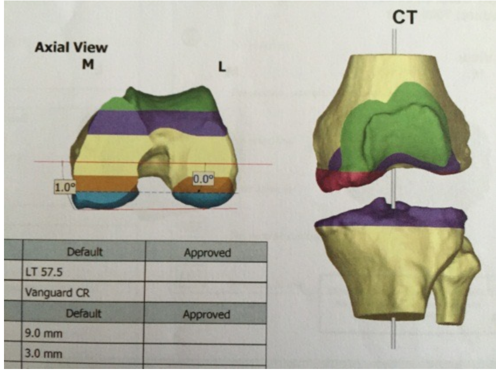
Song Gong[1] · Weihua Xu[1] · Ruoyu Wang[1] · Zijian Wang[1] · Bo Wang[2] · Lizhi Han[1] · Guo Chen[1]

a

Study or Subgroup	PSI Mean	PSI SD	PSI Total	SI Mean	SI SD	SI Total	Weight	Mean Difference IV, Random, 95% CI
De 2017	0.85	2.27	20	1.65	1.97	24	3.5%	-0.80 [-2.07, 0.47]
Huijbregts 2016	0.5	0.2	69	0.9	0.2	64	29.6%	-0.40 [-0.47, -0.33]
Khuangsirikul 2014	1.04	0.62	40	1.58	1.75	40	11.7%	-0.54 [-1.12, 0.04]
Kosse 2017	1.6	2.1	21	1.2	2.7	21	2.7%	0.40 [-1.06, 1.86]
Roh 2013	0.5	1.8	42	1.2	2.4	48	6.6%	-0.70 [-1.57, 0.17]
Silva 2014	0	0.74	23	0	0.93	22	14.1%	0.00 [-0.49, 0.49]
Van 2017	1.3	1.7	44	1.1	2.1	50	7.9%	0.20 [-0.57, 0.97]
Victor 2014	0.5	2.1	61	1.6	2.3	64	7.9%	-1.10 [-1.87, -0.33]
Woolson 2014	0.8	0.75	22	1.7	0.78	26	16.0%	-0.90 [-1.33, -0.47]
Total (95% CI)			**342**			**359**	**100.0%**	**-0.46 [-0.71, -0.21]**

Heterogeneity: Tau² = 0.05; Chi² = 15.30, df = 8 (P = 0.05); I² = 48%
Test for overall effect: Z = 3.57 (P = 0.0004)

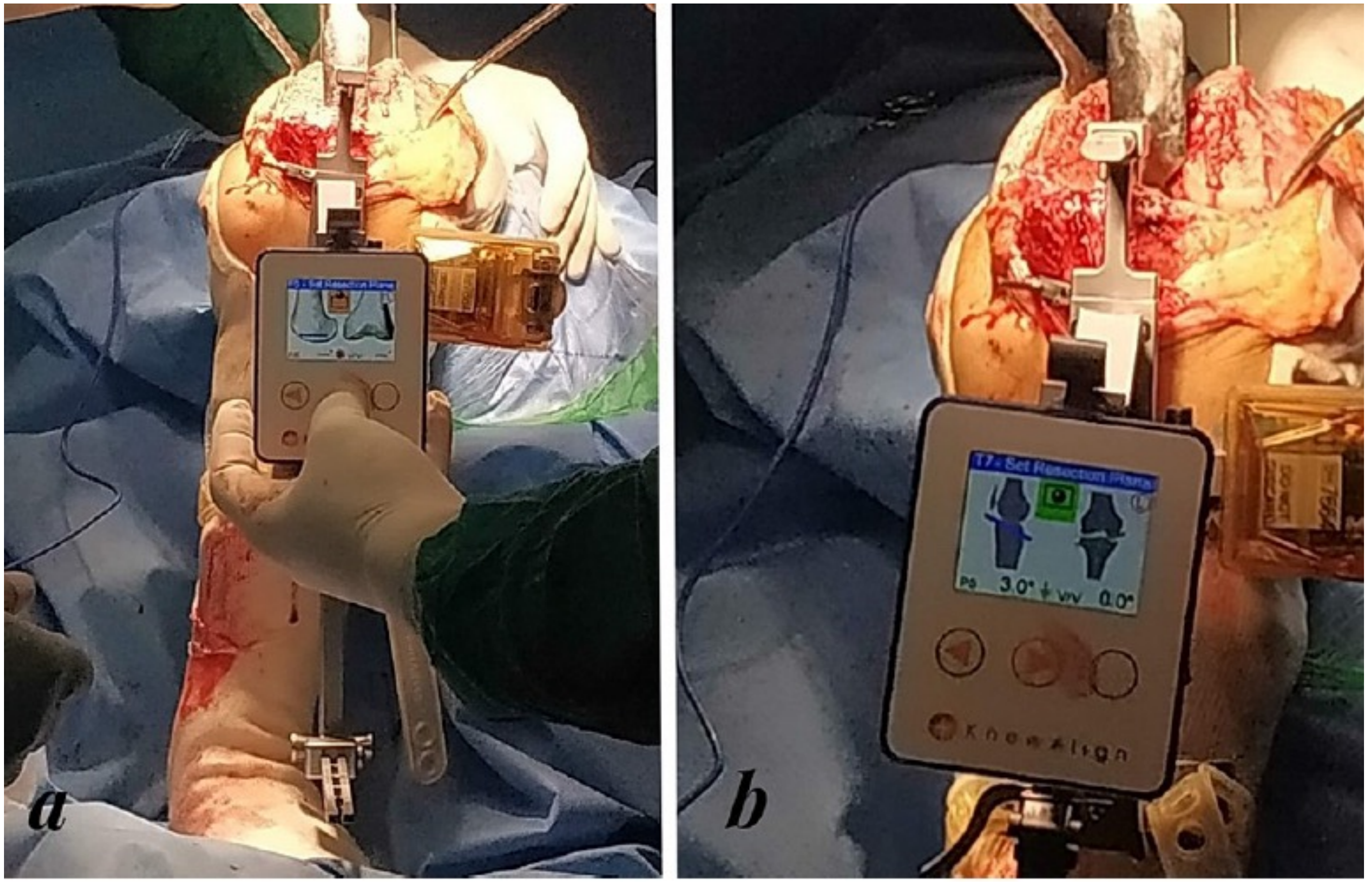




ACCELEROMETER

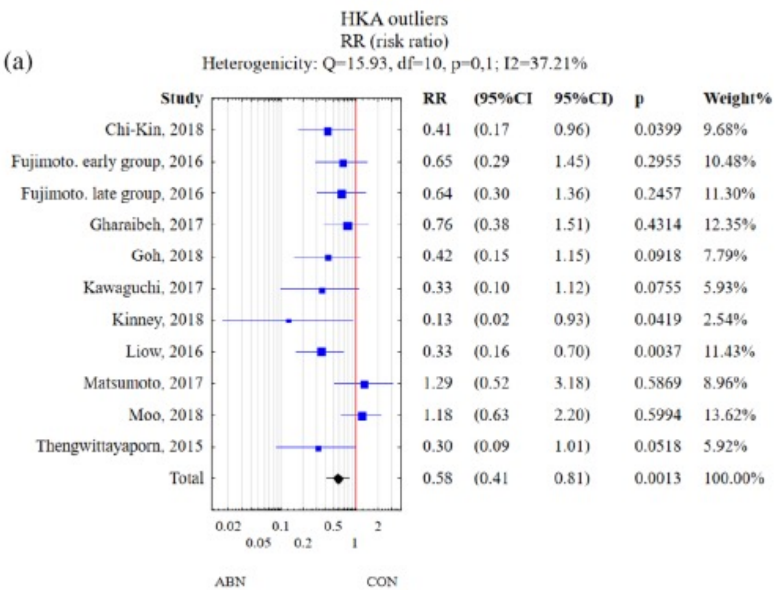
ABN (Accr Based Navigation): KneeAlign 2, iAssist

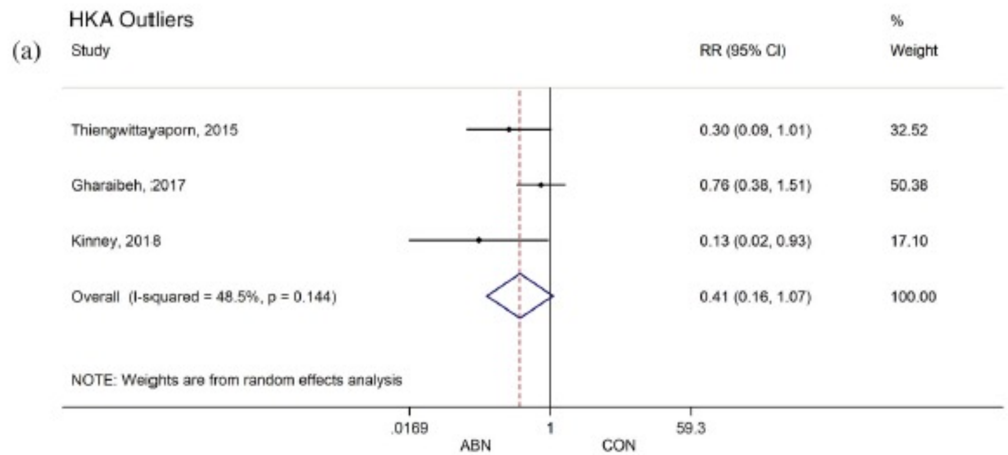
- Display console, reference
- Sensor and attachments to tibial and femoral jigs



ACCELEROMETER

- Improvement in coronal alignment (RR 0.5 outliers)
- Not useful in saggital or axial alignment





ORIGINAL ARTICLE

ANZJSurg.com

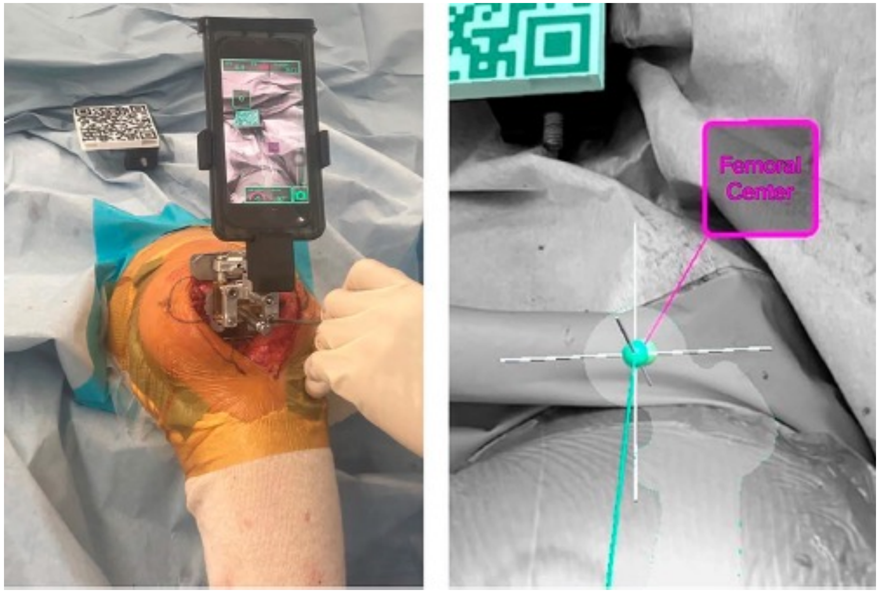
Handheld, accelerometer-based navigation versus conventional instrumentation in total knee arthroplasty: a meta-analysis

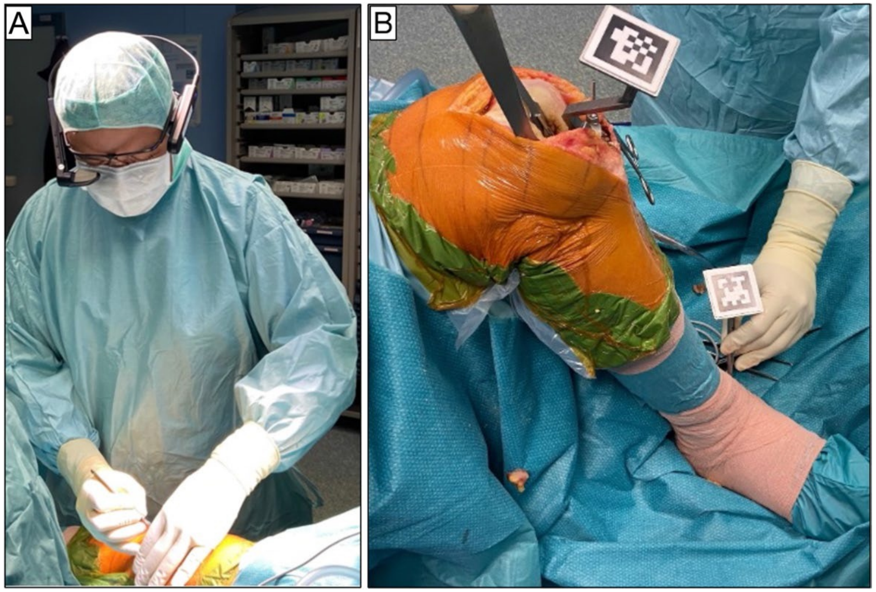
Zaid Shihab,* Catriona Clayworth* and Naveen Nara*†‡

AUGMENTED REALITY

Based on QR codes

Alignment in surgeon's smart-glasses





JB&JS
OPEN ACCESS

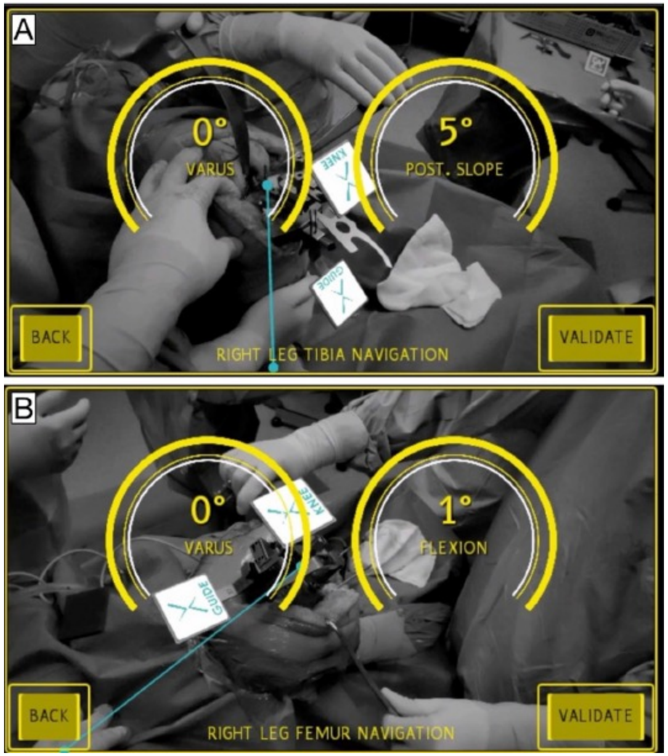
Augmented Reality-Assisted Femoral Bone Resection in Total Knee Arthroplasty

Sachiyuki Tsukada, MD, PhD, Hiroyuki Ogawa, MD, Masahiro Nishino, MD, Kenji Kurosaka, MD, and Naoyuki Hirasawa, MD, PhD

AUGMENTED REALITY

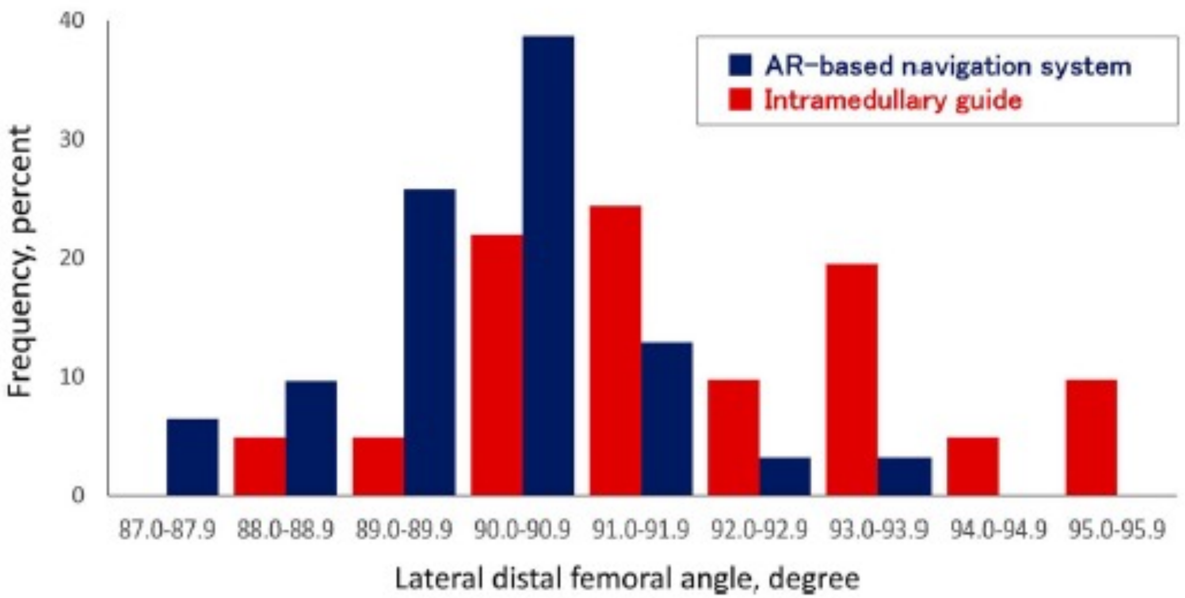
Images also seen in any screen

Menu navigation: head movements



AUGMENTED REALITY

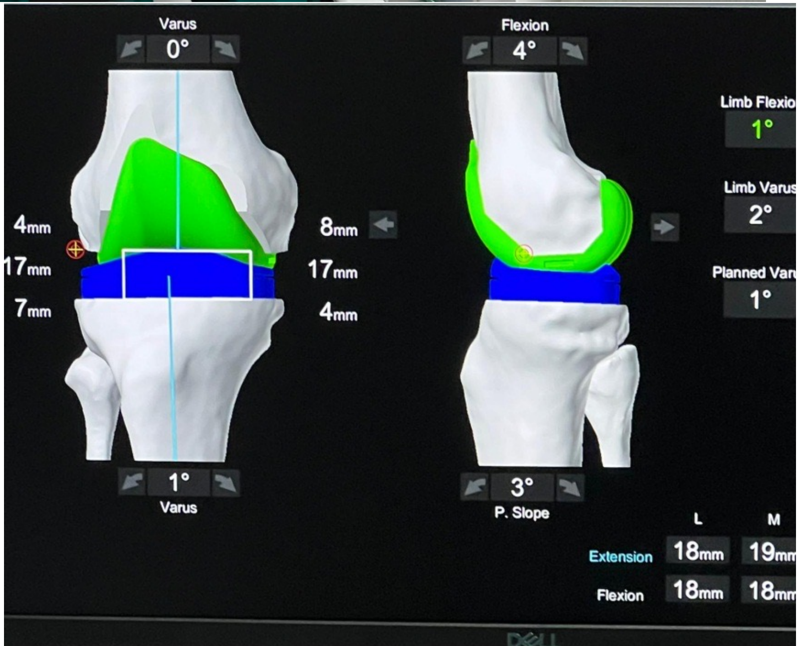
- Short experience – Few cases
- "Open system"
- Improvement in coronal alignment precision (mean error 1.1º vs 2.2º Conv)
- Not useful for rotational alignment



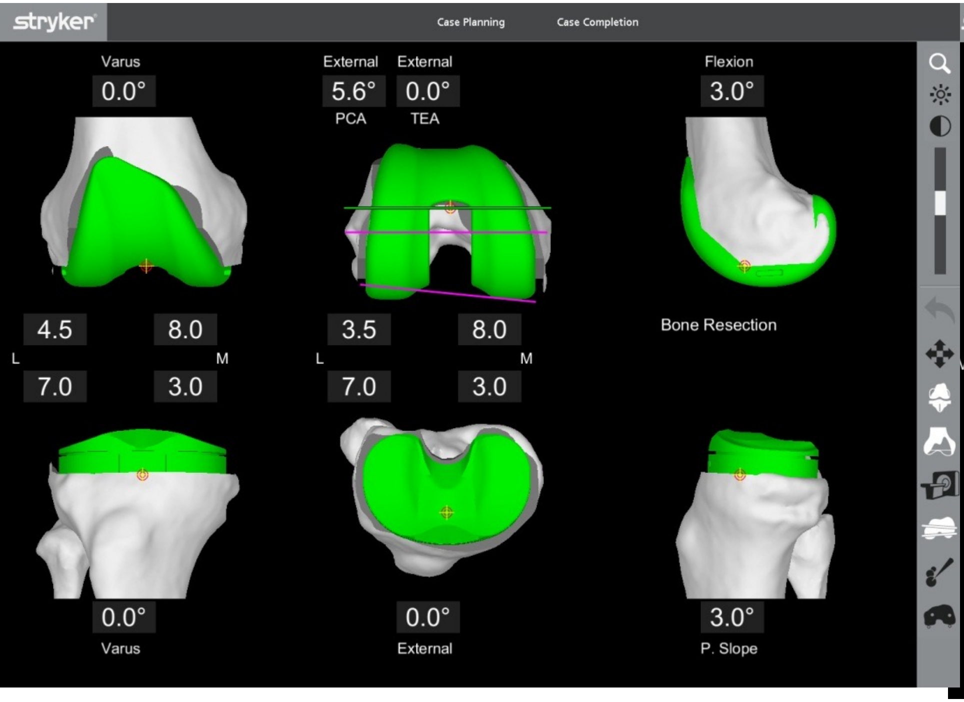
ROBOT SURGERY

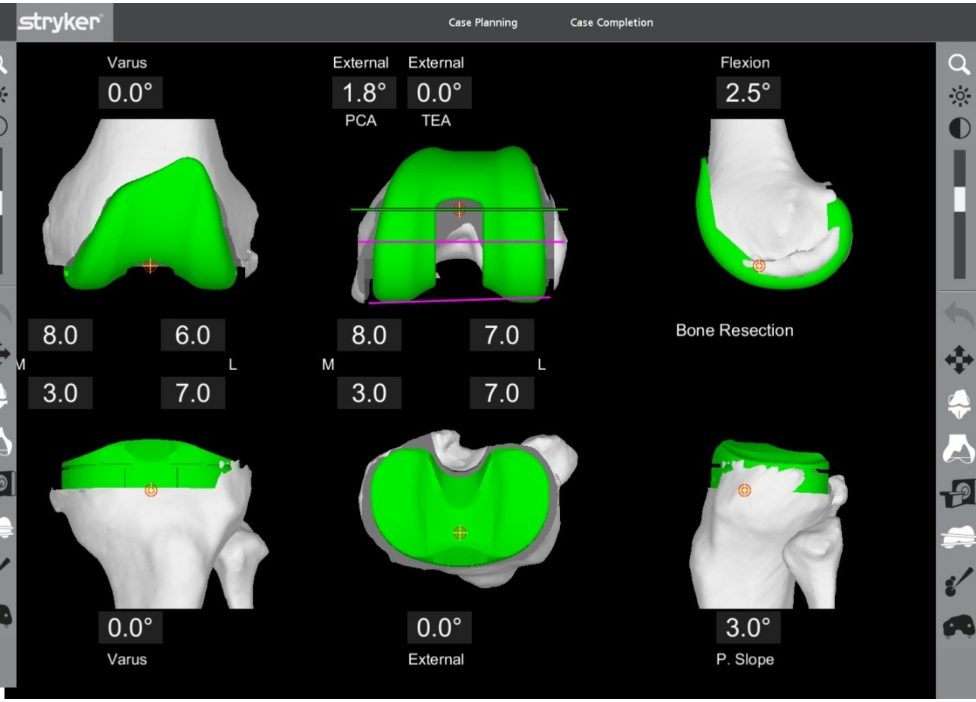
Name	Manufacturer	Introduction year	Platform	Indication	FDA clearance	Type	Technique	Image
TSolution-One	THINK Surgical Inc. Fremont, CA	2015	Open	THA, TKA	THA: 2015 TKA: 2019	Active	Milling	CT
ROSA	Zimmer Biomet Warsaw, IN	2018	Closed	TKA	2019	Active	Cutting guide	XR
Mako	Stryker Mahwah, NJ	2005	Closed	UKA PFA TKA THA	2015	Semi-active	Saw burr	CT
Navio	Smith & Nephew Memphis, TN	2012	Closed	UKA PFA TKA	2017	Semi-active	Burring	Image Free
OMNIBotic BalanceBot	Corin Tampa, FL	2004	Closed	TKA	2017	Semi-active	Cutting guide	CT
Orthotaxy	DePuy Synthes Warsaw, IN	–	Closed	UKA TKA	–	Semi-active	Saw	N/A
CORI	Smith & Nephew Memphis, TN	–	Closed	UKA TKA	–	Semi-active	Burring	Image free

ROBOT SURGERY

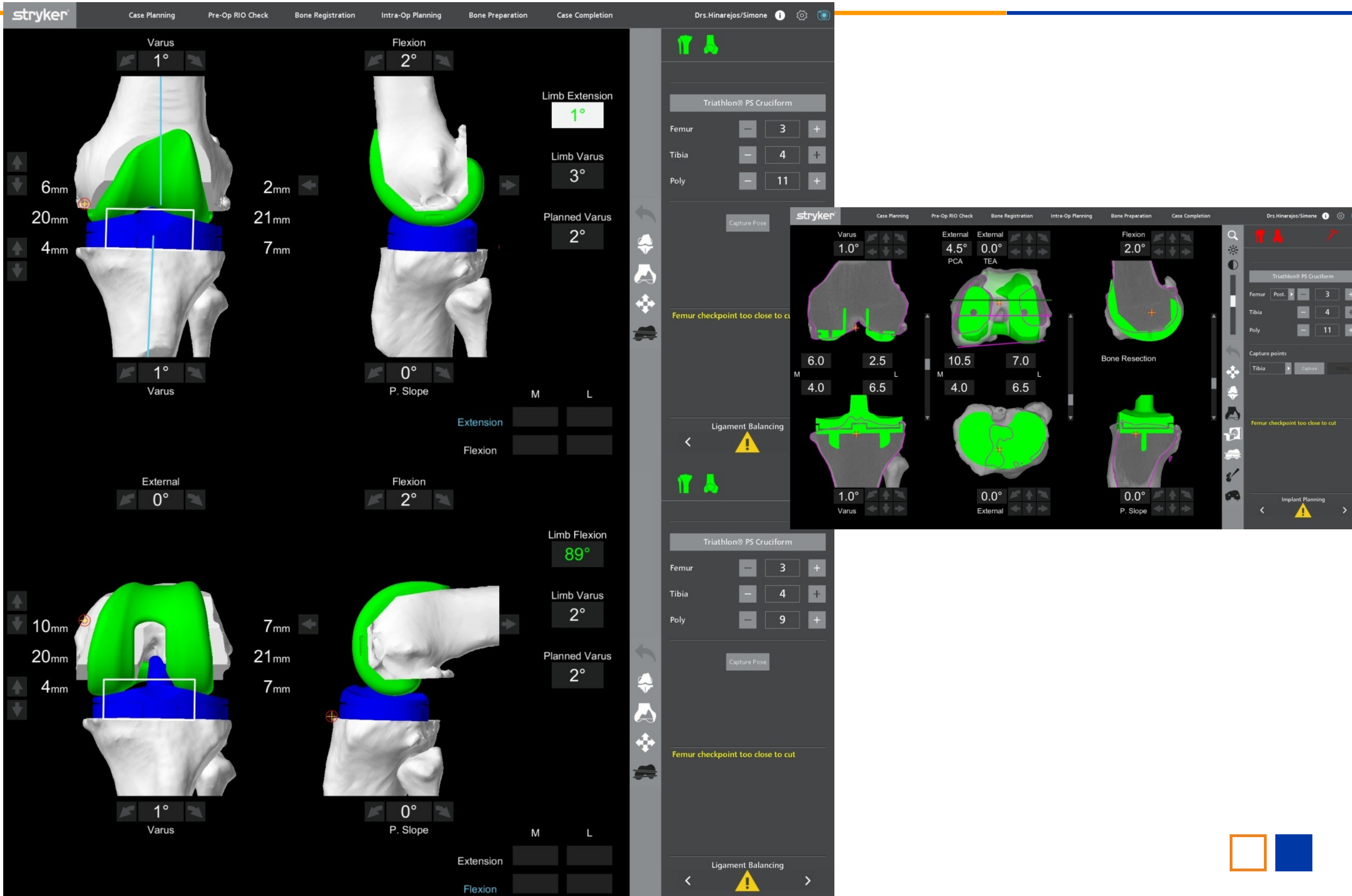


ROBOT SURGERY





ROBOT SURGERY



ROBOT SURGERY

b	n^{i}	Agarwal et al			n^{i}	Chin et al			n^{i}	Gao et al			n^{i}	Onggo et al			n^{i}	Ren et al			n^{i}	Mannan et al		
		ES	*p* value	For		ES	*p* value	For		ES	*p* value	For		ES	*p* value	For		ES	*p* value	For		ES	*p* value	For
Component positioning and alignment																								
Deviation (degrees)																								
HKA angle, WMD					6	-0.71	0.003	**RA**									6	-0.71	0.040	**RA**	5	-0.63	0.020	**RA**
FMA, WMD					6	0.71	n.s										3	-0.75	<0.001	**RA**				
Femoral flexum angle, WMD					6	-1.07	0.010	**RA**									5	-1.06	0.040	**RA**				
TM, WMD					6	-0.60	<0.00001	**RA**									5	-0.50	0.003	**RA**				
Tibial slope, WMD					6	-0.33	n.s										5	-1.32	n.s					
Outliers (> 3°)																								
HKA angle, WOR	8	0.19	<0.00001	**RA**	4	0.19^{ii}	<0.00001	**RA**	4	0.11	<0.05	**RA**	8	0.34	<0.001	**RA**	5	0.11	<0.00001	**RA**	5	0.04	<0.00001	**RA**
FMA, WOR					4	0.29^{ii}	0.020	**RA**					7	0.47	0.002	**RA**	3	0.13	<0.001	**RA**				
Femoral flexum angle, WOR					4	0.27^{ii}	<0.00001	**RA**	3	1.01	n.s		7	0.46	n.s		3	0.14	<0.001	**RA**				
TMA, WOR					4	0.17^{ii}	n.s		3	0.48	<0.05	**RA**	6	0.69	n.s		3	0.13	0.005	**RA**				
Tibial slope, WOR					4	0.35^{ii}	n.s		3	0.48	<0.05	**RA**	7	0.35	0.010	**RA**	3	0.14	<0.001	**RA**				

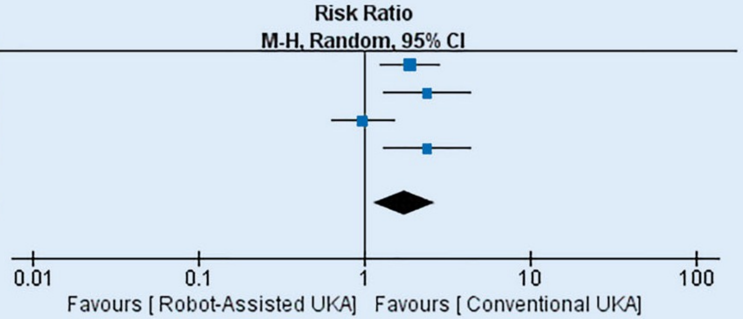
Robot-assisted knee arthroplasty improves component positioning and alignment, but results are inconclusive on whether it improves clinical scores or reduces complications and revisions: a systematic overview of meta-analyses

Nanne Kort[1] · Patrick Stirling[2] · Peter Pilot[3] · Jacobus Hendrik Müller[2]

ROBOT SURGERY- UKA

Study or Subgroup	Robot-Assisted UKA Events	Robot-Assisted UKA Total	Conventional UKA Events	Conventional UKA Total	Weight	Risk Ratio M-H, Random, 95% CI
Bell 2016	40	62	20	58	28.5%	1.87 [1.25, 2.79]
Cobb 2006	13	13	6	15	22.0%	2.37 [1.30, 4.33]
MacCallum 2016	23	87	48	177	27.6%	0.97 [0.64, 1.49]
Rodriguez 2005	13	13	6	15	22.0%	2.37 [1.30, 4.33]
Total (95% CI)		**175**		**265**	**100.0%**	**1.73 [1.12, 2.69]**
Total events	89		80			

Heterogeneity: $\tau^2 = 0.13$; $\chi^2 = 9.41$, df = 3 (P = 0.02); $I^2 = 68\%$
Test for overall effect: Z = 2.46 (P = 0.01)



Orthopäde
https://doi.org/10.1007/s00132-018-3604-x

Jun Fu[1] · Yuning Wang[2] · Xiang Li[1] · Baozhan Yu[1] · Ming Ni[1] · Wei Chai[1] · Libo Hao[1] · Jiying Chen[1]

[1] Department of Orthopaedics, Chinese People's Liberation Army General Hospital (301 Hospital), Beiji China

[2] Clinical Department of Surgery, Chinese People's Liberation Army General Hospital (301 Hospital), Beijing, China

Robot-assisted vs. conventional unicompartmental knee arthroplasty

Systematic review and meta-analysis

Liu *et al. Arthroplasty* (2021) 3:15
https://doi.org/10.1186/s42836-021-00071-x

Arthroplasty

REVIEW Open Access

Robotic-assisted unicompartmental knee arthroplasty: a review

Check for updates

Pei Liu[1], Fei-fan Lu[2], Guo-jie Liu[1], Xiao-hong Mu[3], Yong-qiang Sun[1], Qi-dong Zhang[4], Wei-guo Wang[4] and Wan-shou Guo[4*]

WHICH NEW TECH IS THE BEST?

Comparisons	Risk ratio	95% CI
Accelerometer vs. navigation	1.27	0.63 to 2.52
Accelerometer vs. patient-specific instrumentation	0.59	0.29 to 1.19
Accelerometer vs. robot-assisted navigation	3.46	0.34 to 108.7
Accelerometer vs. standard	0.57	0.29 to 1.09
Navigation vs. patient-specific instrumentation	0.46	0.34 to 0.63
Navigation vs. robot-assisted navigation	2.68	0.29 to 80.36
Navigation vs. standard	0.45	0.37 to 0.53
Patient-specific instrumentation vs. robot-assisted navigation	5.61	0.63 to 174.1
Patient-specific instrumentation vs. standard	0.96	0.74 to 1.23
Robot-assisted navigation vs. standard	0.17	0.01 to 1.48

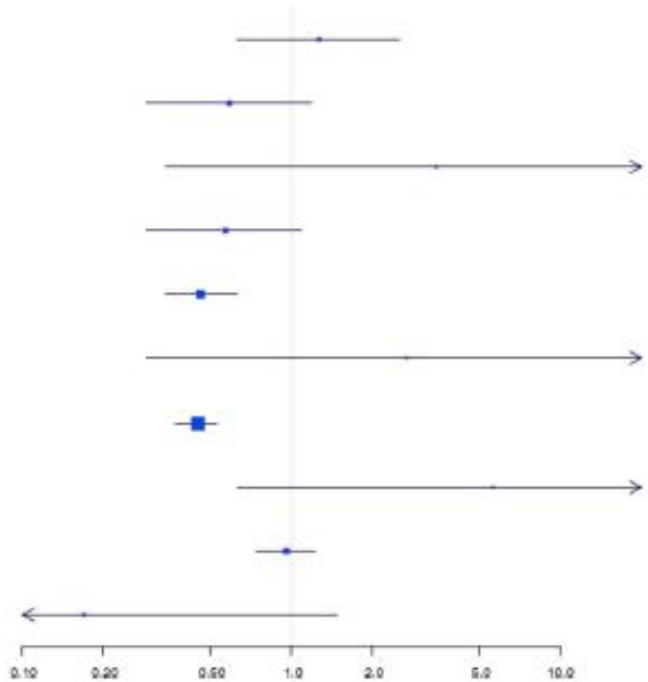


Fig. 3 Forest plots in the network meta-analysis of the relative risks of HKA misalignments between the different cutting guides are shown. The data are presented as risk ratios with 95% credibility intervals, which were obtained using random effects models. The I^2 of the network meta-analysis was 19%.

Systematic Review or Meta-analysis

Are There Differences in Accuracy or Outcomes Scores Among Navigated, Robotic, Patient-specific Instruments or Standard Cutting Guides in TKA? A Network Meta-analysis

Pierre-Alban Bouché BS, Simon Corsia BS, Agnès Dechartres MD, PhD, Matthieu Resche-Rigon MD, PhD, Rémy Nizard MD, PhD

ARTIFICIAL INTELLIGENCE

frontiers in Robotics and AI

ORIGINAL RESEARCH
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Artificial Intelligence Based Patient-Specific Preoperative Planning Algorithm for Total Knee Arthroplasty

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Previous studies have shown that the manufacturer's default preoperative plans for total knee arthroplasty with patient-specific guides require frequent, time-consuming changes by the surgeon. Currently, no research has been done on predicting preoperative plans for orthopedic surgery using machine learning. Therefore, this study aims to evaluate whether artificial intelligence (AI) driven planning tools can create surgeon and patient-specific preoperative plans that require fewer changes by the surgeon. A dataset of 5409 preoperative plans, including the manufacturer's default and the plans corrected by 39 surgeons, was collected. Features were extracted from the preoperative plans that describe the implant sizes, position, and orientation in a surgeon- and patient-specific

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Arthroplasty

REVIEW **Open Access**

Artificial intelligence in knee arthroplasty: current concept of the available clinical applications

Cécile Batailler[1,2*], Jobe Shatrov[1,3], Elliot Sappey-Marinier[1,2], Elvire Servien[1,4], Sébastien Parratte[5,6] and Sébastien Lustig[1,2]

Abstract

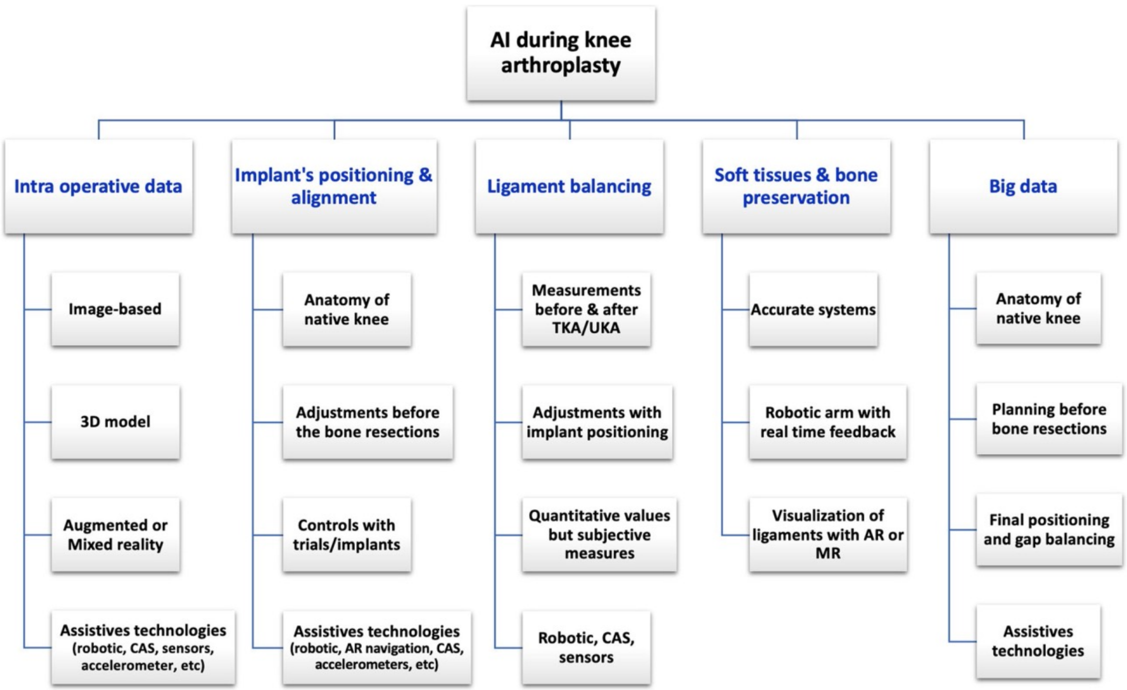
Background: Artificial intelligence (AI) is defined as the study of algorithms that allow machines to reason and perform cognitive functions such as problem-solving, objects, images, word recognition, and decision-making. This study aimed to review the published articles and the comprehensive clinical relevance of AI-based tools used before, during, and after knee arthroplasty.

Methods: The search was conducted through PubMed, EMBASE, and MEDLINE databases from 2000 to 2021 using the 2009 Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocol (PRISMA).

Results: A total of 731 potential articles were reviewed, and 132 were included based on the inclusion criteria and exclusion criteria. Some steps of the knee arthroplasty procedure were assisted and improved by using AI-based tools. Before surgery, machine learning was used to aid surgeons in optimizing decision-making. During surgery, the robotic-assisted systems improved the accuracy of knee alignment, implant positioning, and ligamentous balance. After surgery, remote patient monitoring platforms helped to capture patients' functional data.

Conclusion: In knee arthroplasty, the AI-based tools improve the decision-making process, surgical planning, accuracy, and repeatability of surgical procedures.

Keywords: Knee arthroplasty, Artificial intelligence, Machine learning, Predictive models, Augmented reality, Robotic surgery



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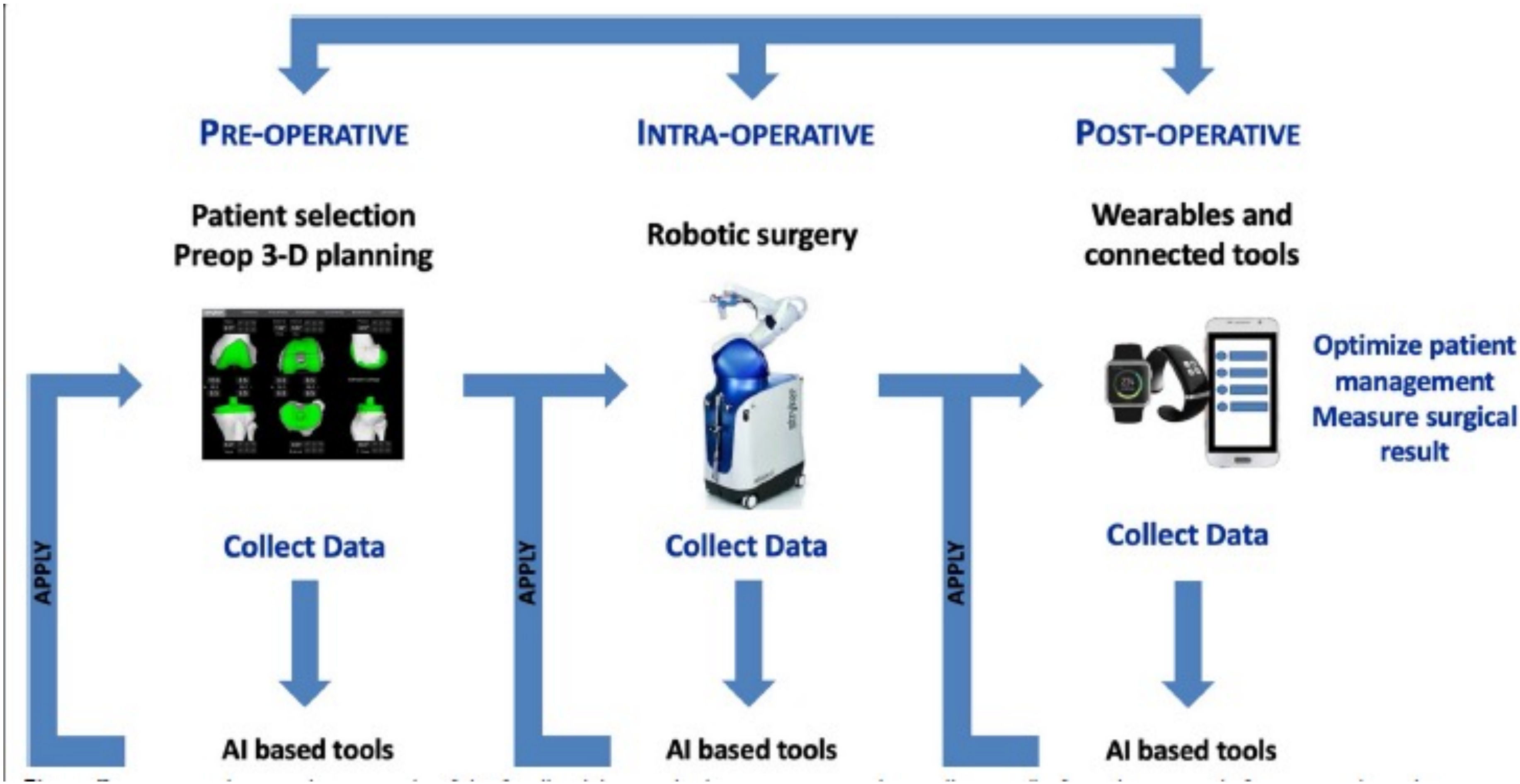
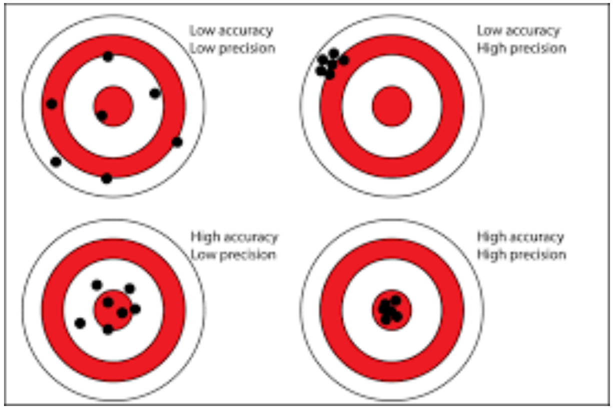


TAKE HOME MESSAGE

- PSI no advantage in TKA alignment
- Navigation, Accel, Aug Reality and Robotics IMPROVE chosen TKA alignment

** Artificial intelligence can improve the decision of which alignment to choose



THANK YOU for your ATTENTION

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