



Comparison of the Positional Accuracy of Robotic-Guided Dental Implant Placement with Static and Dynamic Guided Systems: A Systematic Review

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BACKGROUND

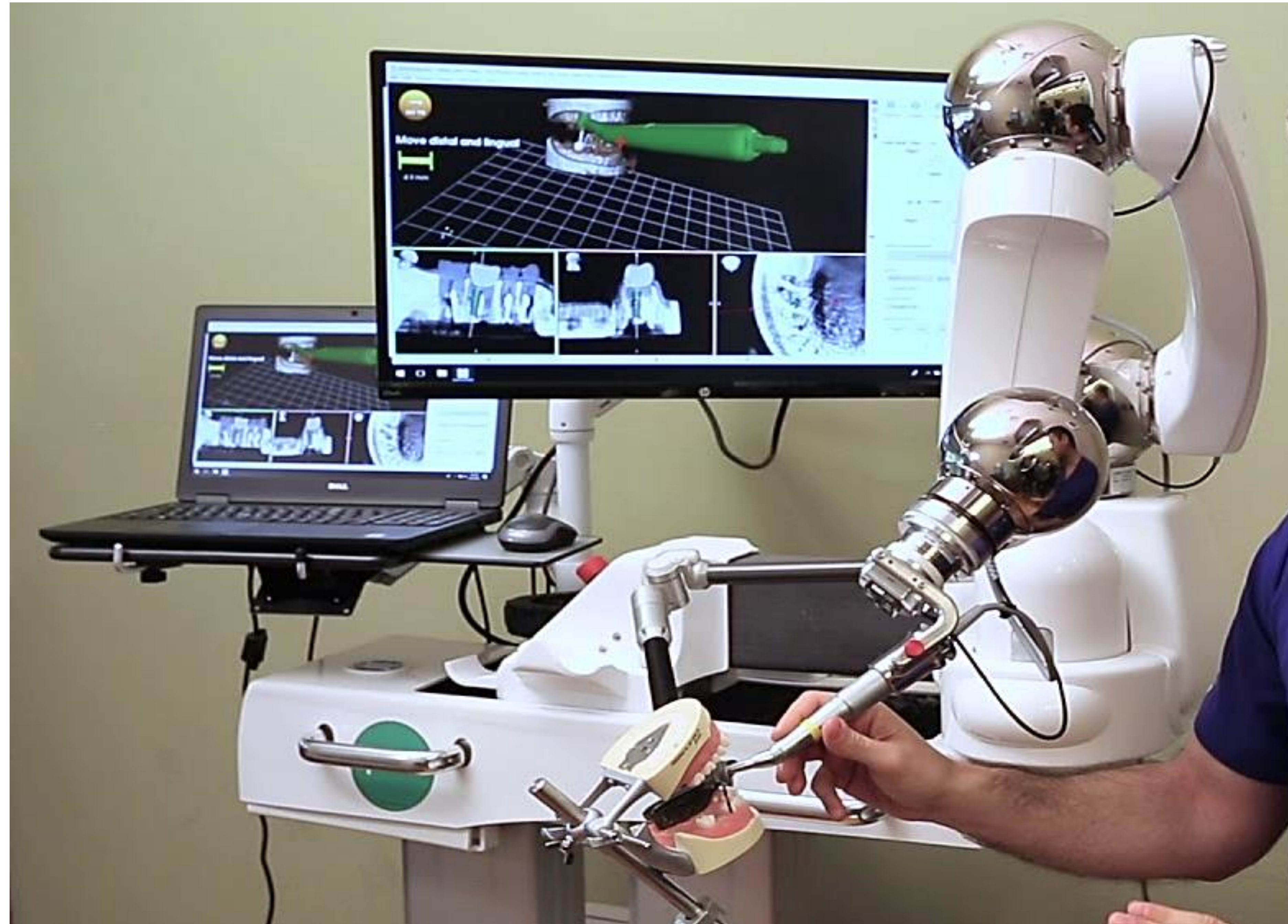
Guided Implant Placement Methods



Static guided: Patient-specific surgical guides allow the transfer of the pre-planned implant position



Dynamic Navigation: Real-time computer assisted surgery that uses optical tracking for navigation tracking



Robot-Assisted: The robot physically guides the surgeon according to the pre-planned implant position

Literature Review

Accuracy of Dental Implant Surgery Using Dynamic Navigation and Robotic Systems: An *In-vitro* Study

Journal of Dentistry
January 2022
Baoxin Tao, Yuan Feng, Xingqi Fan

Conclusion

- The implant positioning accuracy of the robotic system was superior to that of the dynamic navigation system, suggesting that this prototype robotic system (HRS-DIS) could be a promising tool in dental implant surgery

Tao B, Feng Y, Fan X, Zhuang M, Chen X, Wang F, Wu Y. Accuracy of dental implant surgery using dynamic navigation and robotic systems: An in vitro study. J Dent. 2022 7:104170.

Accuracy of Surgical Robot System Compared to Surgical Guide for Dental Implant Placement: A Pilot Study

Journal of implantology and applied sciences
March 2022
Xun Jin, Ryan Jin-Young Kim, Ji-Man Park

Conclusions

- No statistically significant differences were found between the robotic and surgical guide group
- The accuracy in implant placement using robot-assisted implant surgery was comparable to that of static-guided surgery

Jin, Xun, Ryan Jin-Young Kim, Ji-Man Park, Ui-Won Jung, Jae-Kook Cha, June-Sung Shim, and Seong-Joo Heo. "Accuracy of Surgical Robot System Compared to Surgical Guide for Dental Implant Placement: A Pilot Study." (2022): 27-38.

Review Question

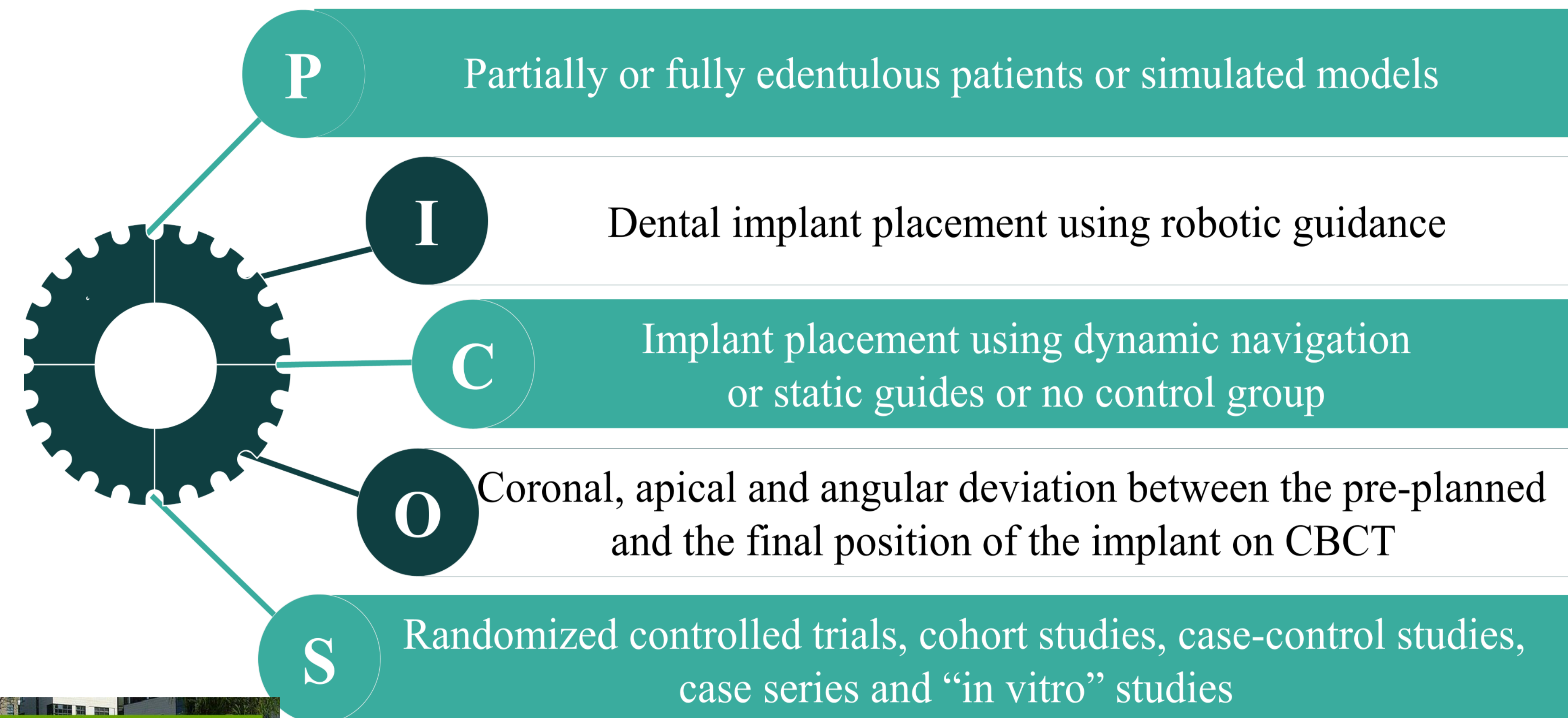
What is the positional accuracy of robotic guided dental implant placement when compared with static guided or dynamic navigation systems?

METHODOLOGY

Objective:

To analyze the positional accuracy of dental implants placed using robotic-guidance with those placed using static guides or dynamic navigation

PICOS Model



P. P, problem, population I. Intervention (treatment or procedure) C. Control O. Outcome S. Study designs

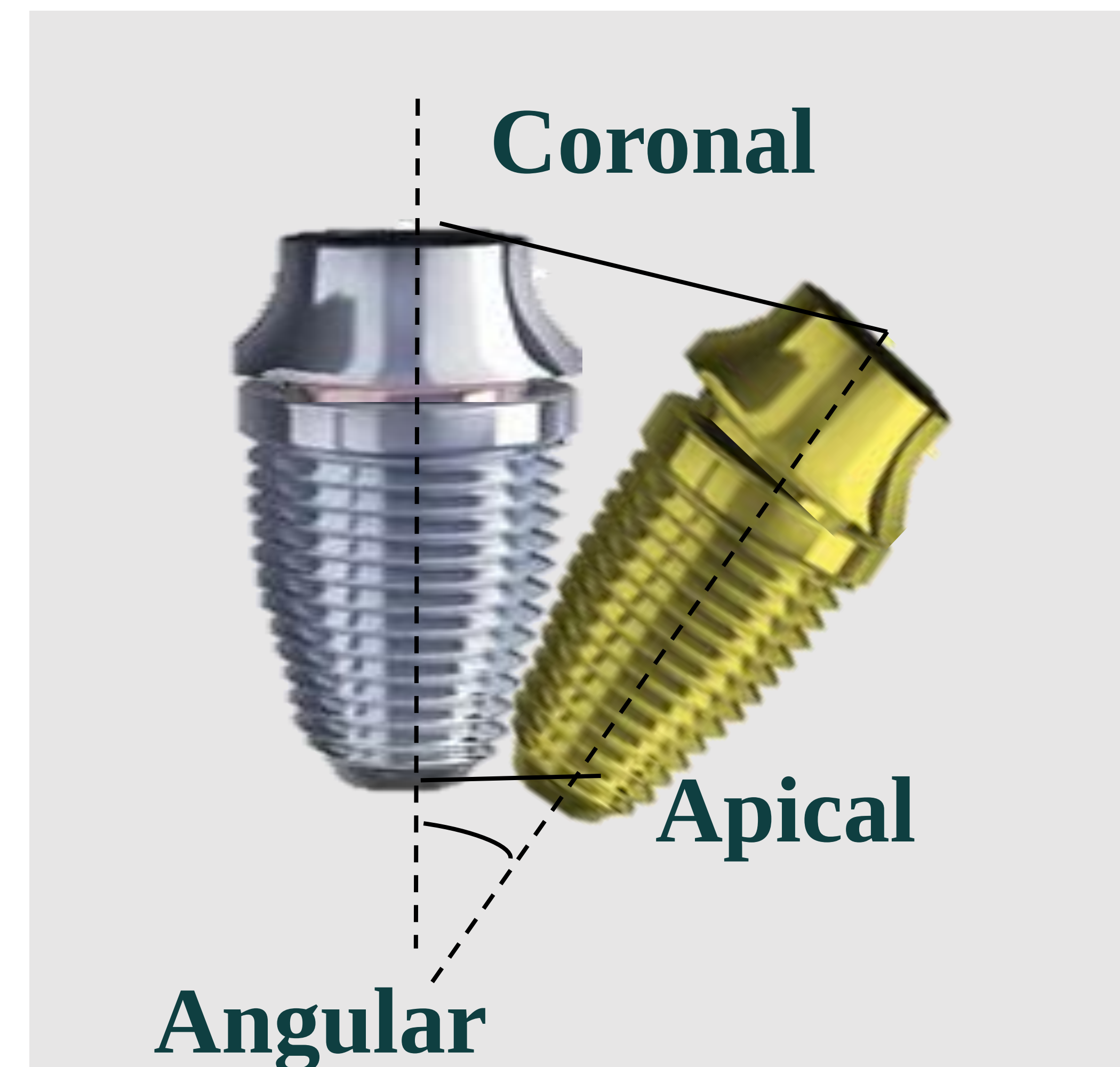
Search Strategy



[(Dynamic OR Static OR Robot* OR Hapt* OR Navig*) AND (Guide* OR Surgical Guide OR Stent OR Implant*) AND (Outcome OR success OR survival OR failure OR deviation OR Accura* OR result*) AND (Dental OR Dent* OR Oral OR Oral Surgery)]

NOT (Endo* OR Knee OR Iapro* OR Hip OR Hepato* OR Pyelo* OR Review)]

Positional Accuracy



Inclusion Criteria

Clinical trials, longitudinal studies, in-vitro studies and animal studies

Studies in English language

Reporting of the mean deviation of dental implants from pre planned position

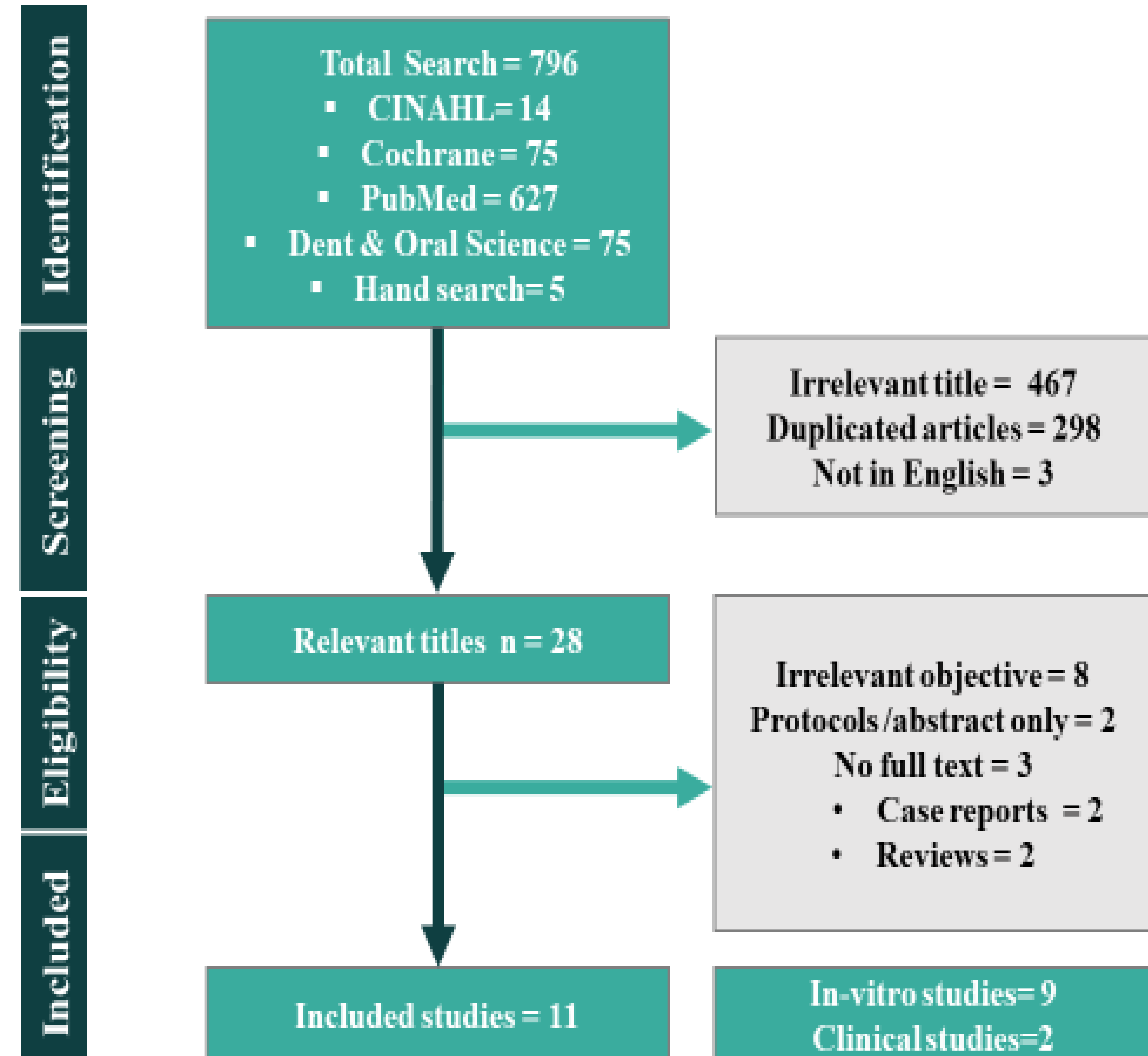
Exclusion Criteria

Case reports and Case series (n<5)

Review articles and abstracts

Studies reporting outcomes other than mean deviation of implant placement

PRISMA Flowchart



RESULTS

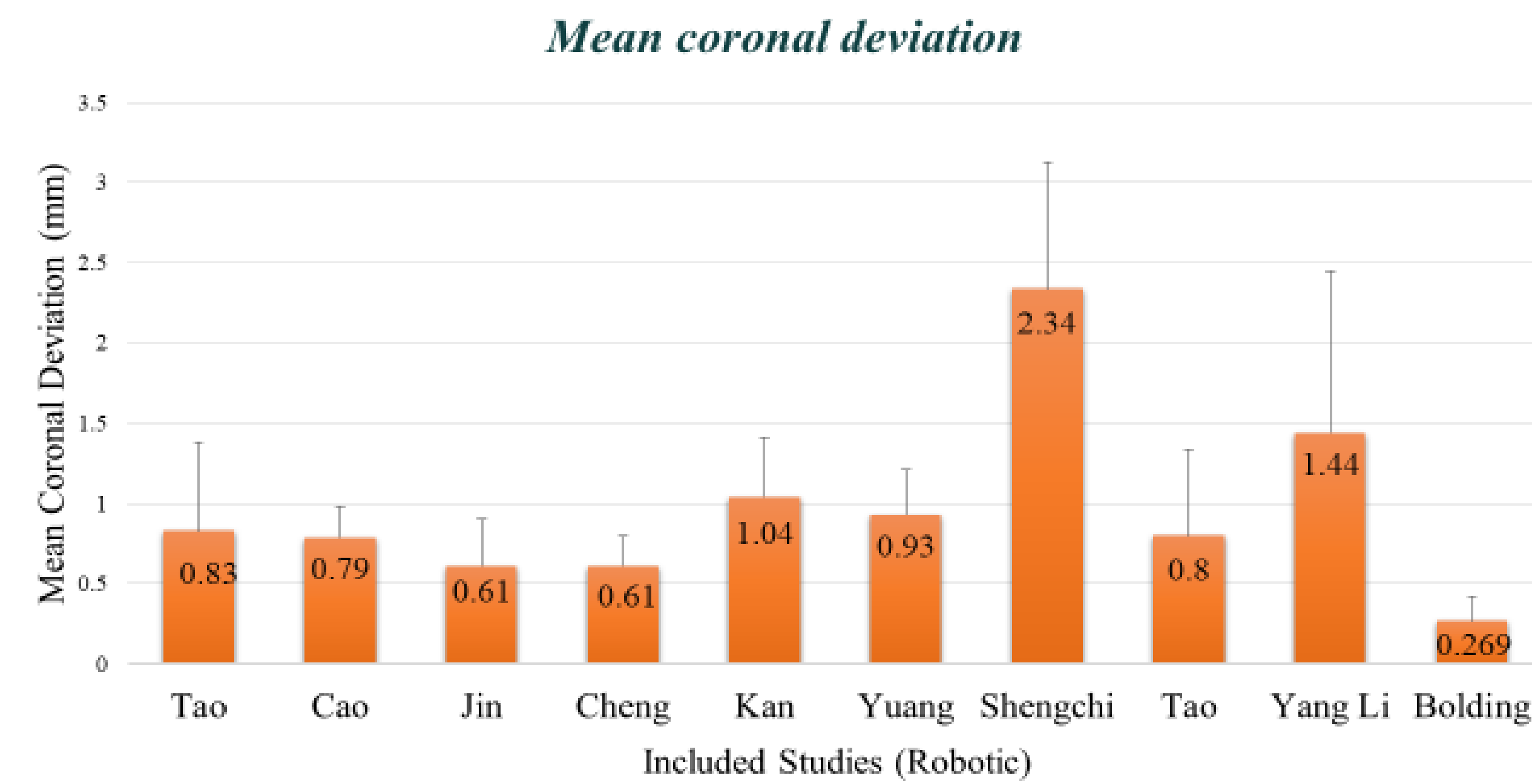
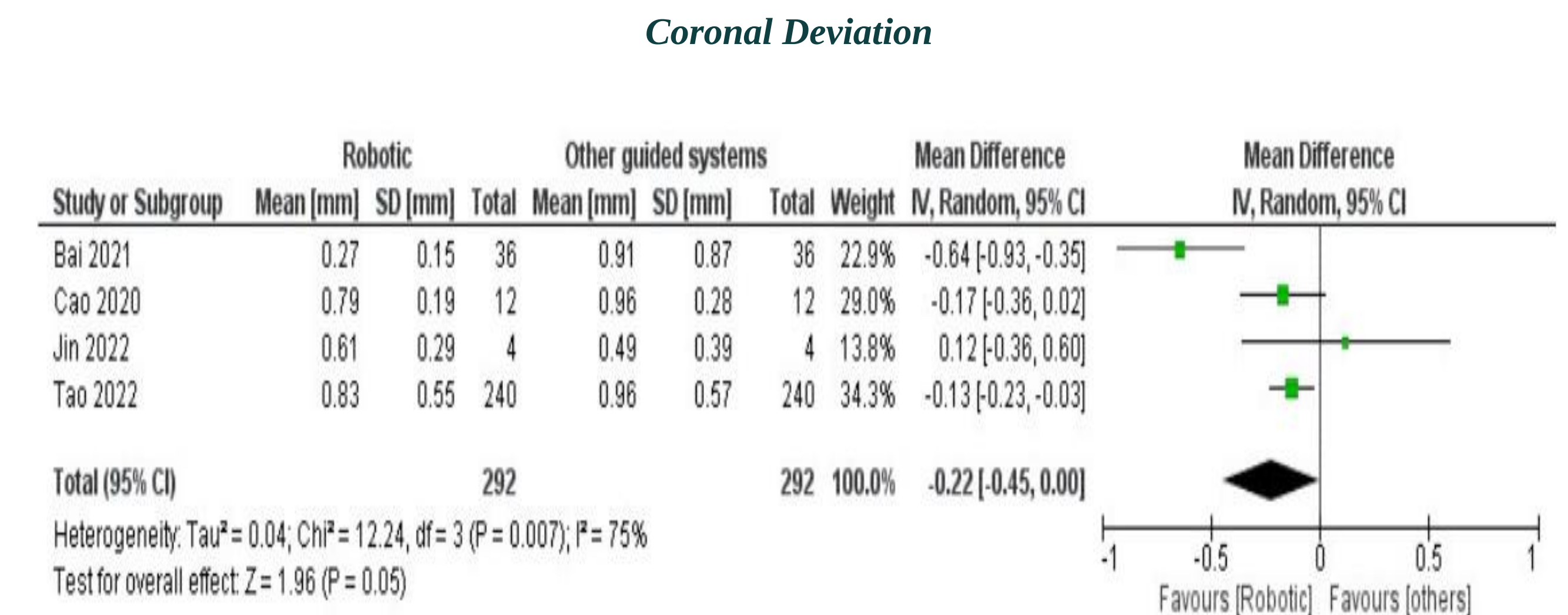
Included Studies

No.	Author	Year	Journal	Study Type
1	Tao <i>et al.</i>	2022	Journal of Dentistry	Double arm in-vitro
2	Jin <i>et al.</i>	2022	Journal of Implantology and Applied Sciences	Double-arm in vitro
3	Tao <i>et al.</i>	2022	International Journal of Medical Robotics	Single arm in-vitro
4	Cheng <i>et al.</i>	2021	Computers in Biology and Medicine	Single arm in-vitro
5	Kan <i>et al.</i>	2021	Int Journal of Medical Robotics and computer	Single arm in-vitro
6	Yuan <i>et al.</i>	2021	Int Journal of Computer Assisted Radiology and Surgery	Single arm in-vitro
7	Bai <i>et al.</i>	2021	Chinese Journal of Stomatology	Double arm Clinical
8	Cao <i>et al.</i>	2020	Medical Engineering and Physics	Double arm in-vitro
9	Bolding <i>et al</i>	2021	Journal of Prosthetic Dentistry	Single arm Clinical
10	Yang Li <i>et al.</i>	2020	Int Journal of Computer Assisted Radiology and Surgery	Single arm in-vitro
11	Shengchi <i>et al.</i>	2018	Clinical Oral Implant Research	Single arm in-vitro

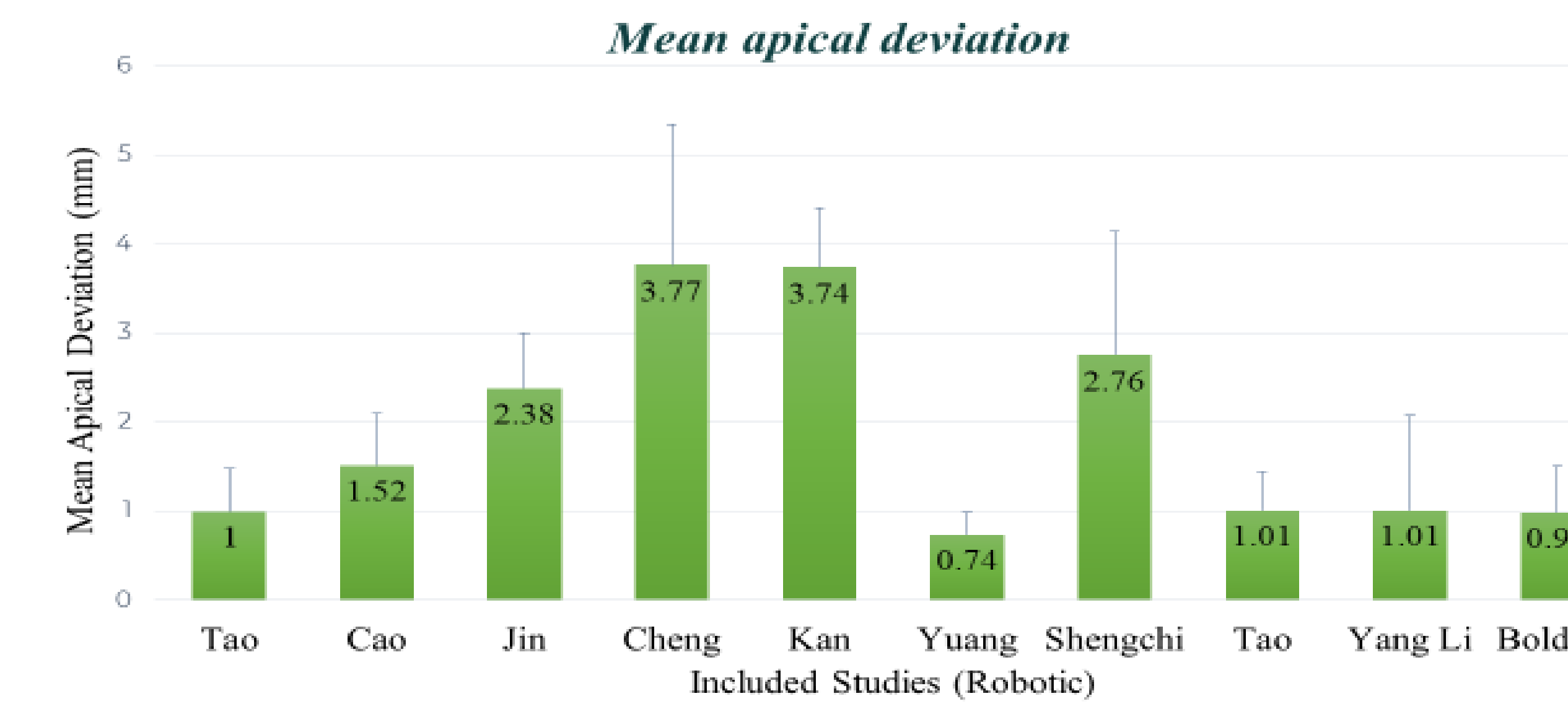
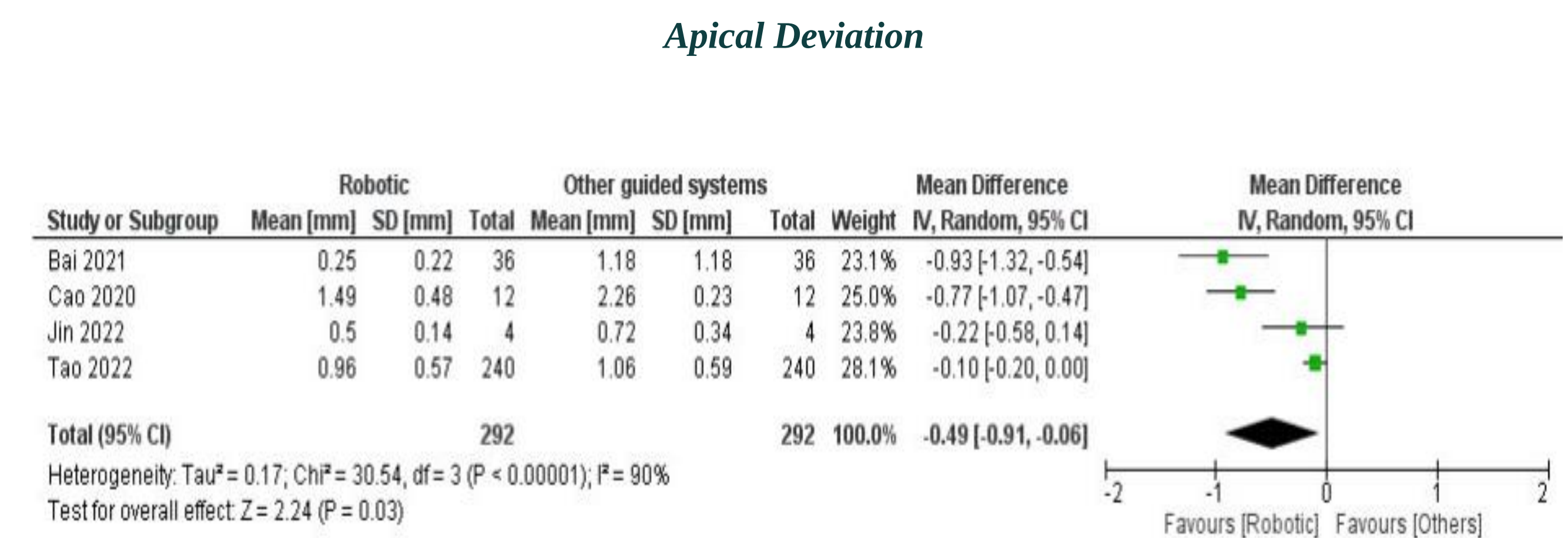
No.	Study	Study Design; Groups	Robot System	Model Type	No. of Models (M), Implants (I) , Patients (p)	
1.	Tao et al.	In-vitro	Parallel hybrid	3-D printed (EvoLVe) 128 resin	M= 80 ; I=480	
					Dynamic: M=40, I=240	Robotic: M=40, I=240
2	Cao et al.	In-vitro	Autonomous (6 DOF)	3-D printed	M= 4 ; I=16	
					Dynamic M= 1, I= 4	Robotic M= 3, I= 12
3	Jin et al	In-vitro	Autonomous (6 DOF)	3-D printed mandible	M=4 ; I=14	
					Static M= 1, I= 10	Robotic M= 3, I= 4
4	Bai <i>et al</i>	Split mouth clinical study	Autonomous (6 DOF)	Patients	P=18; I=36	
					Static P=18, I= 18	Robotic P=18, I= 18

No.	Study; Implants (n)	Coronal deviation Mean ± SD (mm)		Apical deviation Mean ± SD (mm)		Angular deviation Mean ± SD (°)		Conclusion
1.	Tao <i>et al.</i> N=240	Dynamic 0.96 ± 0.57	Robotic 0.83 ± 0.55	Dynamic 1.06 ± 0.59	Robotic 0.96 ± 0.57	Dynamic 2.41 ± 1.42	Robotic 1 ± 0.48	Robotic-guided showed greater accuracy
2	Cao <i>et al.</i> N=12	Dynamic 0.96 ± 0.28	Robotic 0.79 ± 0.19	Dynamic 2.26 ±0.23	Robotic 1.49 ± 0.48	Dynamic 2.07 ± 0.30	Robotic 1.52 ± 0.58	Robotic-guided showed greater accuracy
3	Jin <i>et al.</i> N=4	Static 0.49 ± 0.39	Robotic 0.61 ± 0.29	Static 0.72 ± 0.34	Robotic 0.50 ± 0.14	Static 3.16 ± 2.36	Robotic 2.38 ± 0.62	Robotic-guided was comparable to static guided
4	Bai <i>et al</i> N=18.	Static 0.91 ± 0.87	Robotic 0.269 ± 0.15	Static 1.18 ± 1.18	Robotic 0.254 ± 0.22	Static 4.21 ± 5.21	Robotic 0.99 ± 0.52	Robotic-guided showed greater accuracy

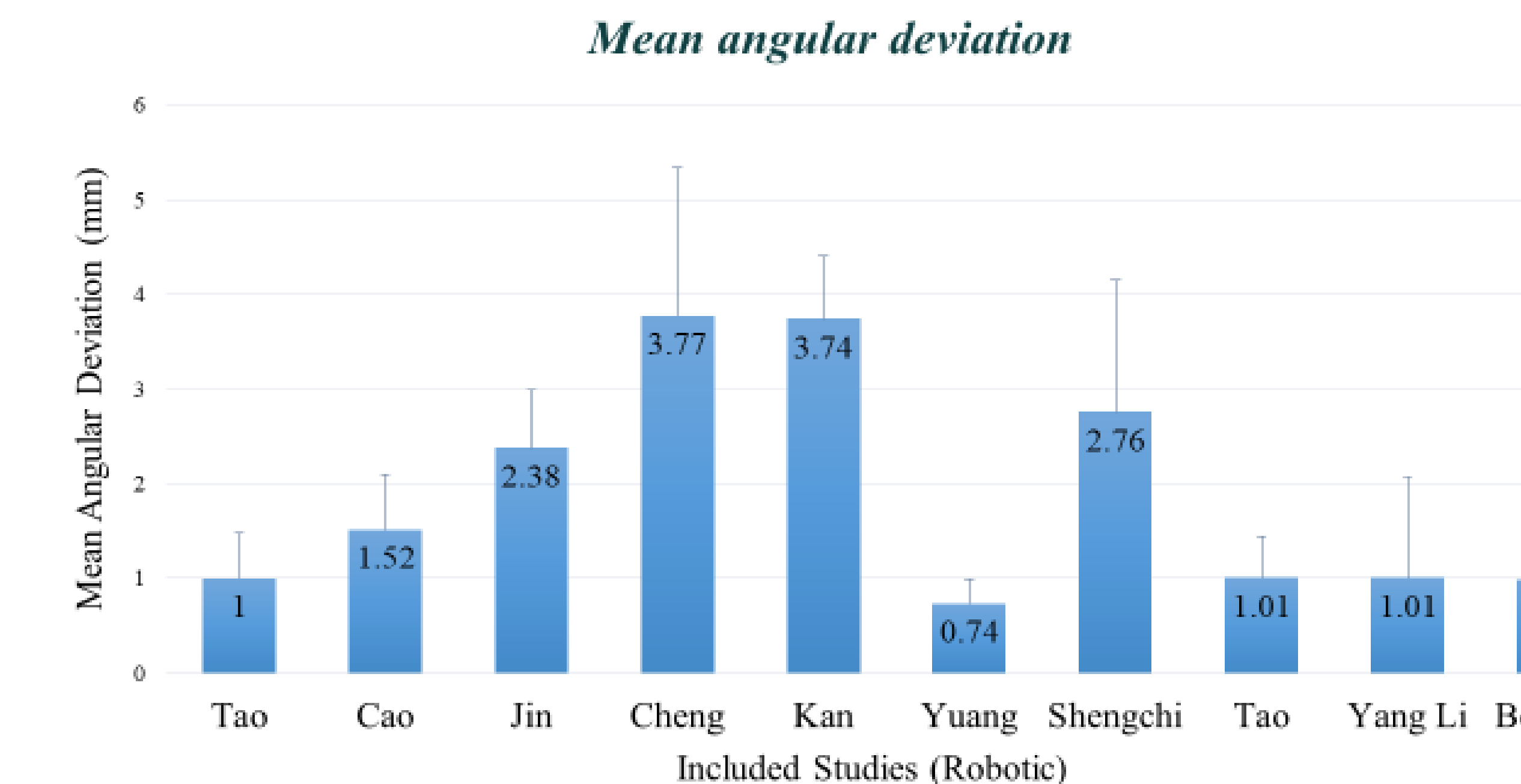
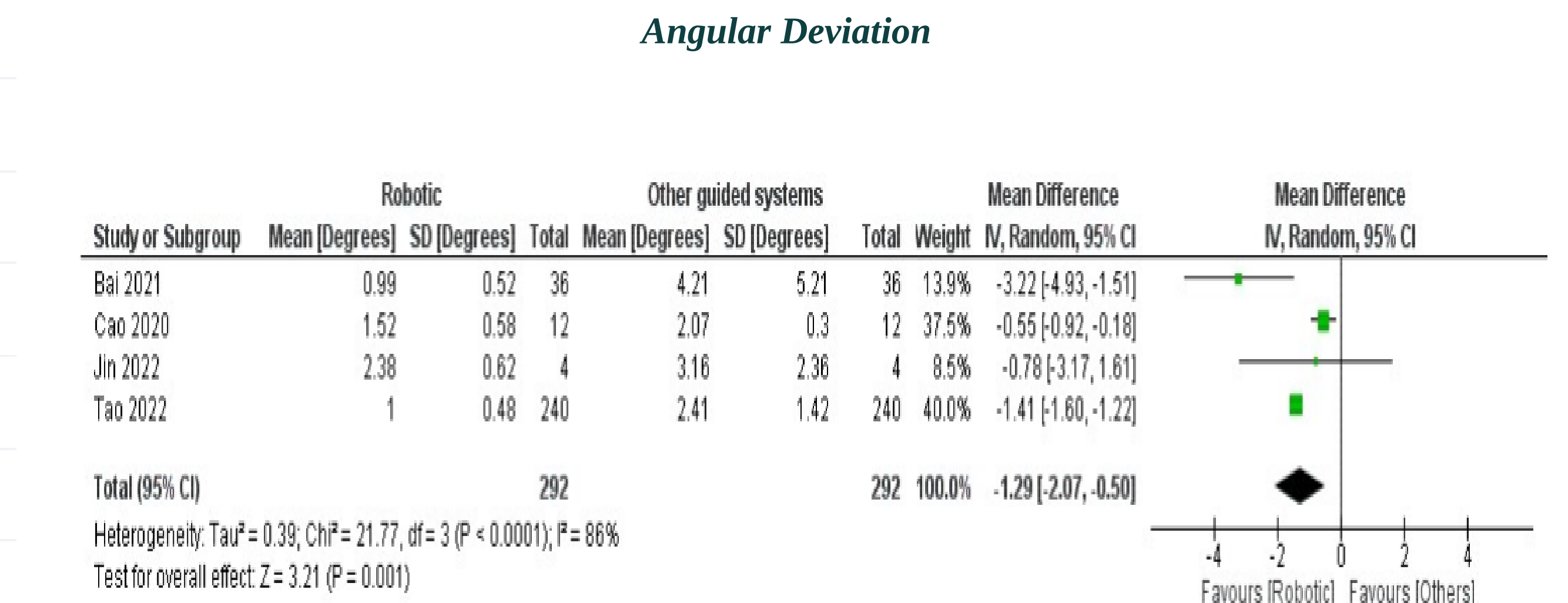
Mean Deviation and Meta-analysis



Forest plot of comparison: 1 Robotic vs Other guided systems, outcome: 1.1 Coronal deviation [mm].



Forest plot of comparison: 1 Robotic vs Other guided systems, outcome: 1.2 Apical deviation [mm].



Forest plot of comparison: 1 Robotic vs Other guided systems, outcome: 1.3 Angular Deviation [Degrees].

DISCUSSION

Limitations

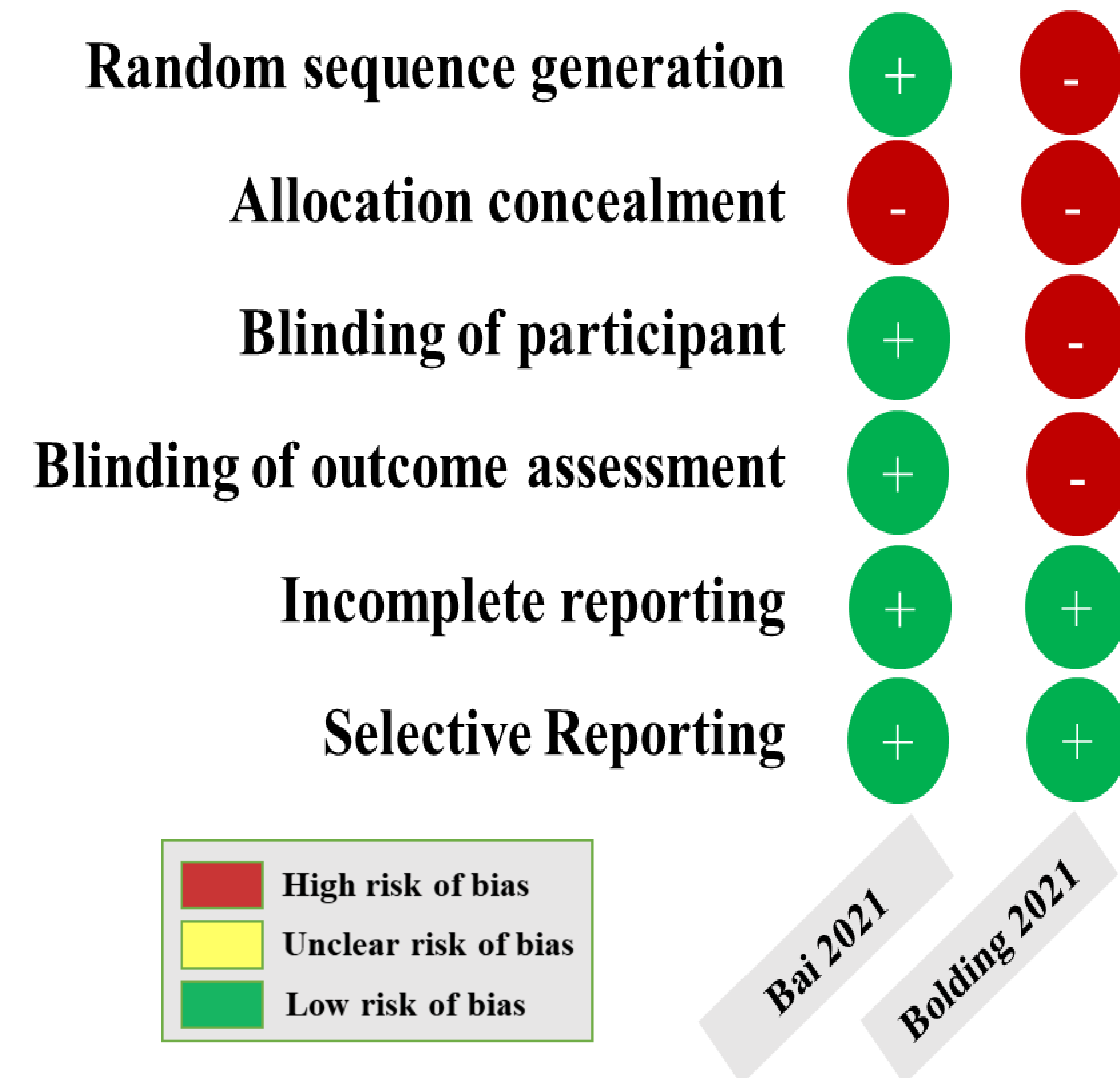
- The number of clinical studies was limited
- Most of the studies were single arm studies, with no control group
- Outcomes such as cost-effectiveness, procedure time have not been reported
- The available literature is heterogenous

Strengths

- First systematic review to assess the accuracy of robotic guided implant placement
- Risk of bias of all studies was carried out using a validated risk of bias tool, which has not been applied in other systematic reviews

Risk of Bias

Clinical Studies



Risk of Bias

In-Vitro Studies (QUIN tool)

	Cao 2020	Cheng 2021	Jin 2022	Kan 2021	Shenchi 2018	Tao 2022	Tao 2022*	Yang Li 2020	Yuan 2021
Clearly stated objectives	2	2	2	2	2	2	2	2	2
Sample size calculation	0	0	0	0	0	0	2	0	0
Sampling technique	X	X	X	X	X	X	X	X	X
Details of comparison group	2	X	1	X	X	2	X	X	X
Explanation of methodology	1	1	2	1	2	2	2	2	1
Operator details	2	1	0	0	1	1	2	2	0
Randomization	X	X	X	X	X	X	X	X	X
Meeasurement of outcome	2	2	2	2	2	2	2	2	2
Outcome assessor details	1	0	0	0	0	1	2	1	0
Blinding	0	0	0	0	0	0	2	0	0
Presentation of Results	2	2	2	2	2	2	2	2	2
Statistical analysis	1	1	2	2	2	2	2	2	2

Overall Risk	
>50%	High risk
50-70%	Medium risk
>70%	Low risk

Sheth VH, Shah NP, Jain R, Bhanushali N, Bhatnagar V. Development and validation of a risk-of-bias tool for assessing in vitro studies conducted in dentistry: The QUIN; 2022 . *J Prosthet Dent.* 2022;S0022-3913(22)345-6

CONCLUSIONS

- Robot-guided dental implant placement improves the apical and angular deviations of dental implants when compared to dynamic guided and static guided implant placement
 - The current quality of evidence is low and requires further investigation