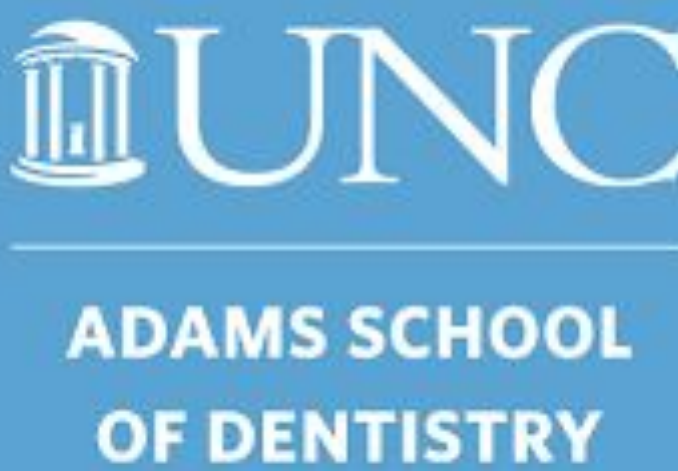
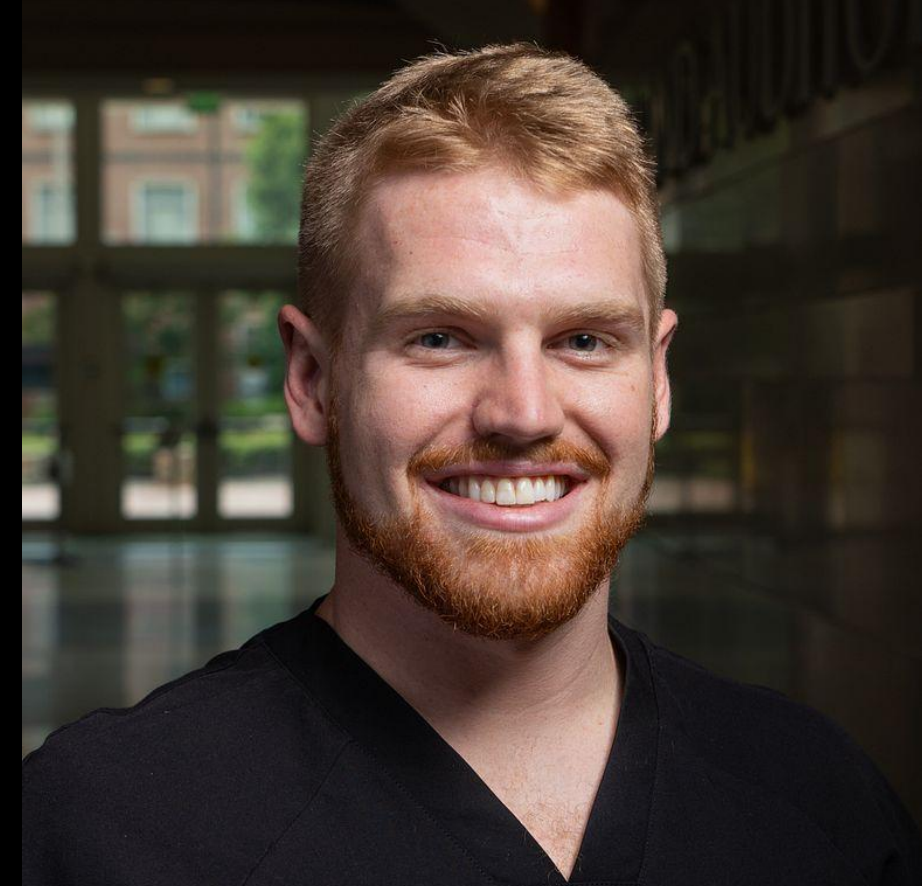




Accuracy of Static Tooth Supported Implant Guides Fabricated Using In-office 3D Printers: A Systematic Review

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Introduction

- Emerging technology in affordable desktop 3D printers has popularized the use of guided implant surgery.
- Using cone-beam computed tomography (CBCT) in conjunction with the intraoral scans or digitized dental casts, clinicians can now plan implant cases and print the surgical guide in-office for guided surgery.
- While the in-office desktop 3D printing technology promises highly accurate/precise implant placement, limited numbers of current studies on the topic exist.
- The main objective of this systematic review was to define current use of in-office desktop 3D printing in guided implant surgery; and the range of implant deviations from the planned positions when an in-office desktop 3D printer was used.

Materials & Methods

- The review of the current literature was done using Pubmed, EMBASE, Web of Science, and Dentistry & Oral Sciences Source (EBSCOHost) databases.
- Two authors (R. A. and R. K. A.) independently screened articles from these databases using titles and abstracts.
- The third author (S.B.) would make the final decision when there was a disagreement.
- The database search was limited to articles published years prior to December 20th, 2019 since affordable in-office desktop 3D printers were introduced in 2016 and after.

Results

Figure 1. Literature Search and Article Selection

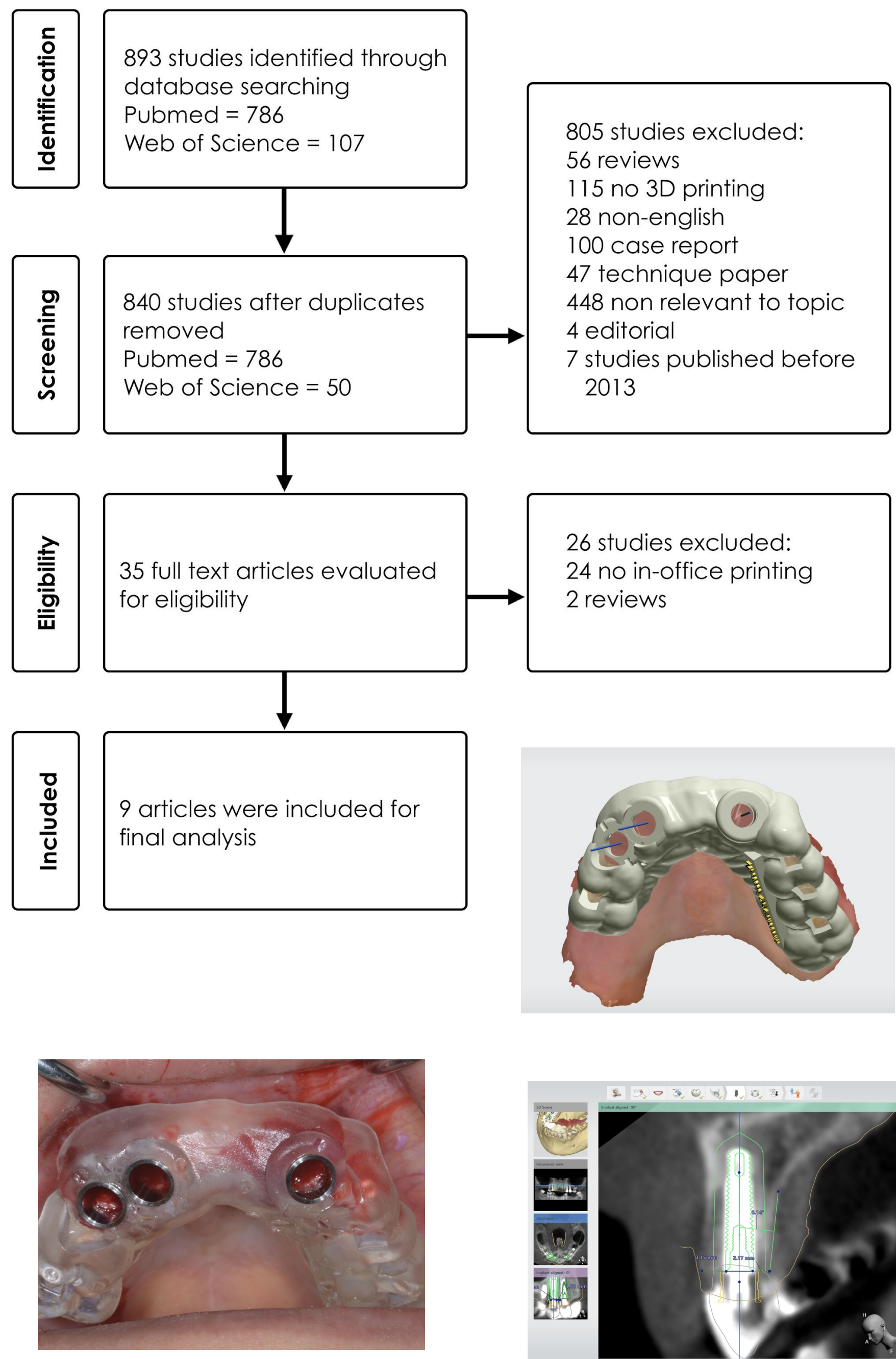


Table 1. Characteristics of samples/subject's population, implant systems, guide system, and 3D printers

Study/Reference #	Samples/Population	Implant System/Manufacturer	CBCT system/	Planning Software/Manufacturer	3D Printer/Manufacturer	Type of Printer	Type of Guide
Bell et al 2018	in vitro 20 implants 4.3mmx8mm Thermoplastic v.s. 3D printing	Tapered Replace Select/ Nobel Biocare	Newtome/ Biolase	BlueSkyBIO	Objet30 Orthodesk/Stratasys	SLA	Both were tooth supported
Bencharit et al 2018	in vivo 31 implants 20 full guided 11 partially guided Fully VS partially guided surgeries	Tapered Internal/BioHorizon Nobel Replace Conical/Nobel Biocare Tapered screw vent/ Zimmer Biomet	iCAT FLX V10	Implant Studio/3Shape	Form 2/Formlabs	SLA	Partially edentulous/Tooth supported; fully guided and partially guided (pilot)
Cristache et al 2017	65 implants Compared the actual placement to the planned placement	AnyRidge (Megagen Implant, Gyeongbuk, Korea) No further info.	ProMax 3D (Planmeca)	software R2GATE version 1.0.0 (Megagen, Gyeongbuk, Korea)	Prefactory/EnvisionTec	SLA	Tooth supported/fully guided Single-tooth.
Deeb et al 2017	in vitro n = 10 3.7x13mm	Tapered screw vent/ Zimmer Biomet	iCAT FLX V10	Implant Studio/3Shape	Form 2/Formlabs	SLA	Single-tooth/Tooth supported; fully guided
Kemen et al 2017	3.8mmx9mm Laboratory temp VS printed temp 34 implants	Guide System CAMLOG® SCREW-LINE Implant	Morita Accutomo 80 (J. Morita)	SMOP, Swissmeda AG, Zürich, Switzerland	Objet Eden 260 V/Stratasys	SLA	Multiple teeth.
Gjelvold et al 2018	10 DLP 10 SLA 3.8x12 mm N = 20 DLP VS SLA	Tapered Internal BioHorizons	ProMax 3D (Planmeca)	Implant Studio/3Shape	Formlabs for SLA Vida; EnvisionTEC for DLP	SLA /DLP	Single-tooth/Tooth supported; fully guided
Suriyan et al 2018	N = 35	CAMLOG BEGO Zimmer Straumann Ostem	DentiScan	Implant Studio/3Shape	Form 2/Formlabs	SLA	Partially edentulous/Tooth supported; trephination based partially guided
Tan et al 2018	N = 26 13 fully guided 13 free hand 4.1 x 8 mm	Straumann RC Bone level	Gendex CB-500	Implant Studio/3Shape	Orthodesk/Stratasys	SLA	Tooth supported single tooth fully guided VS Free hand.

Table 2. Implant placement deviations using guides fabricated by in-office 3D printers

Study/Reference #	Implant width/length	Angulation (°)		Vertical (mm)	Entry (mm)		Apex (mm)	
		Buccolingual	Mesiodistal		Buccolingual	Mesiodistal	Buccolingual	Mesiodistal
Bell et al 2018	4.3x8	2.36±1.38		N/A	0.24±0.24		0.36±0.86	
Bencharit et al 2018	Variable sizes Fully (F) Partially (P)	F: 0.32±2.36 P: 0.59±6.83	N/A	N/A	F: B: 0.23±1.08 F: L: 0.22±1.44 P: B: 0.62±1.15 P: L: 0.28±1.61	F: M: 0.17±0.78 F: D: 0.44±0.78 P: M: 0.28±1.38 P: D: 0.59±1.59	N/A	N/A
Cristache et al 2017	Not reported	2.34±0.85		0.50 ±0.38	0.79±0.52		1.17±0.63	
Deeb et al 2017	3.7x13	3.37±2.58	0.84±1.53	N/A	0.49±0.22	0.28±0.19	N/A	N/A
Gjelvold et al 2018	3.8x12	SLA: 1.25 ±0.49 DLP: 0.99 ±0.57		SLA: 0.34 ±0.18 DLP: 0.16±0.11	SLA: 0.39 ±0.01 DLP: 0.27 ±0.08		SLA: 0.49 ±0.17 DLP: 0.34 ±0.14	
Kemen et al 2017	3.8x9	1.15±1.01		1.15	0.16±0.17	0.23±0.21	0.25±0.27	0.34±0.31
Suriyan et al 2018	Variable sizes With sleeve (S) Without Sleeve (NS)	N/A	N/A	S: 0.58±0.13 NS: 0.51±0.27	S: B: 0.41±0.11 S: L: 0.38±0.13 NS: B: 0.37±0.12 NS: L: 0.39±0.16	S: 0.41±0.07 NS: 0.41±0.12	N/A	N/A
Tan et al 2018	4.1 x 8 mm	3.91 [2.45,5.38]		0.32 [0.13,0.41]	0.42 [0.33,0.48]		0.87 [0.53,1.11]	

Discussion & Conclusion

- Out of the 9 included articles there were 6 3D printers, 4 manufacturers and 5 different planning softwares.
- Most studies used SLA printers but one used a DLP printer.
- The overall accuracy of implant placement ranges are similar to previous studies/systematic reviews. The overall accuracy was within 1-4 degrees of angulation deviations, ~0.3-1.15 mm vertical displacement, ~0.2-0.8 mm horizontal entry deviation, and ~0.4-1.2 mm horizontal apex deviation.
- Guided implant surgery utilizing in-office 3D printers provides accurate static guided implant placement.
- A systematic review is being redone to analyze more recent studies.