

The Accuracy of a Virtual Facebow Record: A Comparison Between Smartphone 3D Scanner and Industrial 3D Scanner

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BACKGROUND

Collecting proper and accurate patient specific information is important for prosthodontic rehabilitation. The three-dimensional position of the maxilla, interarch relationship, reference planes and points of the face greatly influence the prosthetic treatment plan and design. The virtual patient is formulated through the superimposition of various three-dimensional images taken from the live patient by use of a facial scanner, through the application of a virtual facebow technique. A virtual articulator can then be integrated with the virtual patient further assisting CAD/CAM prosthetics.

With the advent of advancements in consumer technology, smartphone devices have gained the capability to perform three-dimensional scanning. In comparison to bulky and costly industrial scanners and stereophotogrammetry devices, smartphones present a cost-effective and user-friendly option. Nonetheless, the equivalence of accuracy between smartphone-based records and industrial scanner based virtual facebow records (VFR) remains uncertain.

OBJECTIVES

To compare the accuracy of virtual facebow records obtained using an industrial 3D scanner with those captured by a smartphone-based 3D scanner.

MATERIAL AND METHODS

Approved by the Institutional Review Boards of the University of Michigan (Study ID: HUM00210049), fifty virtual facebow records were conducted on ten participants utilizing a smartphone 3D scanner and an industrial scanner. Five scans per participant on each device were completed with a virtual facebow attached to their upper arch. Maxillary intraoral scans were obtained and aligned to each subject's face utilizing the facebow fork.

- Trueness and precision were calculated through superimposition to a generated stereolithography face scan calculated from a computed tomography (CBCT) image. Deviations were calculated between points placed on the intraoral scan at #9, #14, and #3 employing a generated Python Script in Blender.
- Deviations were categorized angularly and linearly to compute precision and trueness.
- Further differences were investigated utilizing the Mann-Whitney U test with significance of p value of <0.01.

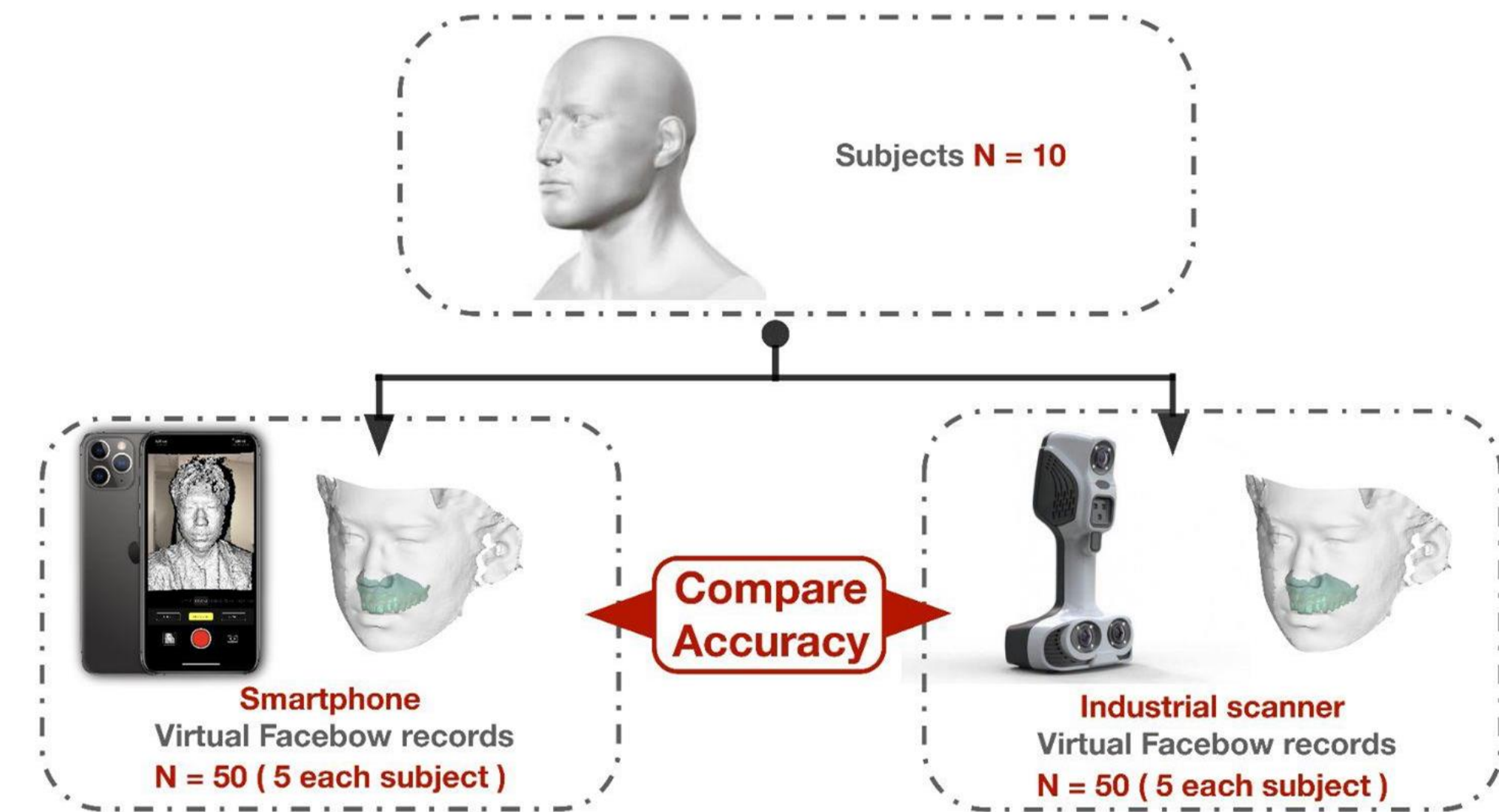


Figure 1. Study design. Two groups (smartphone-based and industrial scanner based) of virtual facebow records were obtained from 10 subjects. Each method was repeated 5 times on each subject. In total, 10 records were obtained from each subject.

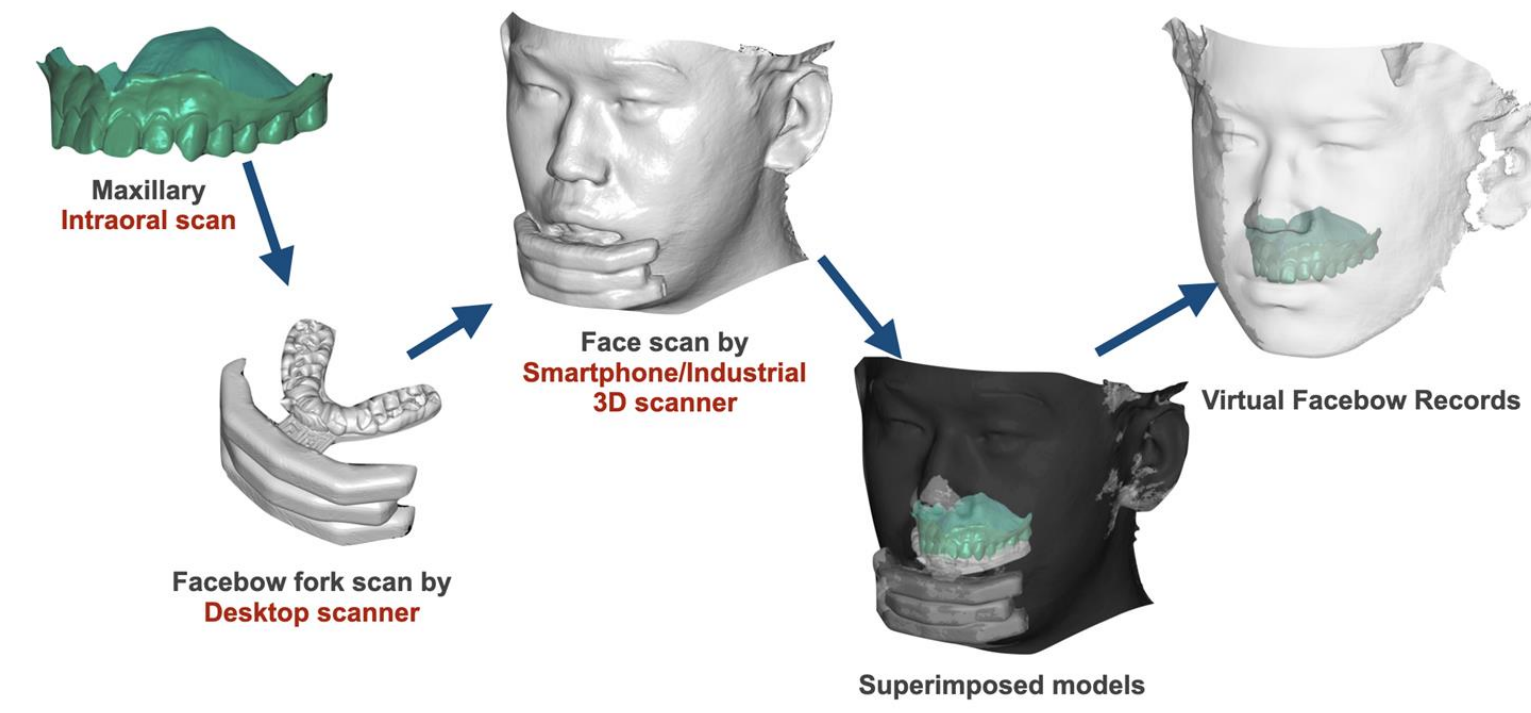


Figure 2. The process of creating virtual facebow records



Figure 3. The industrial scanner in scanning process

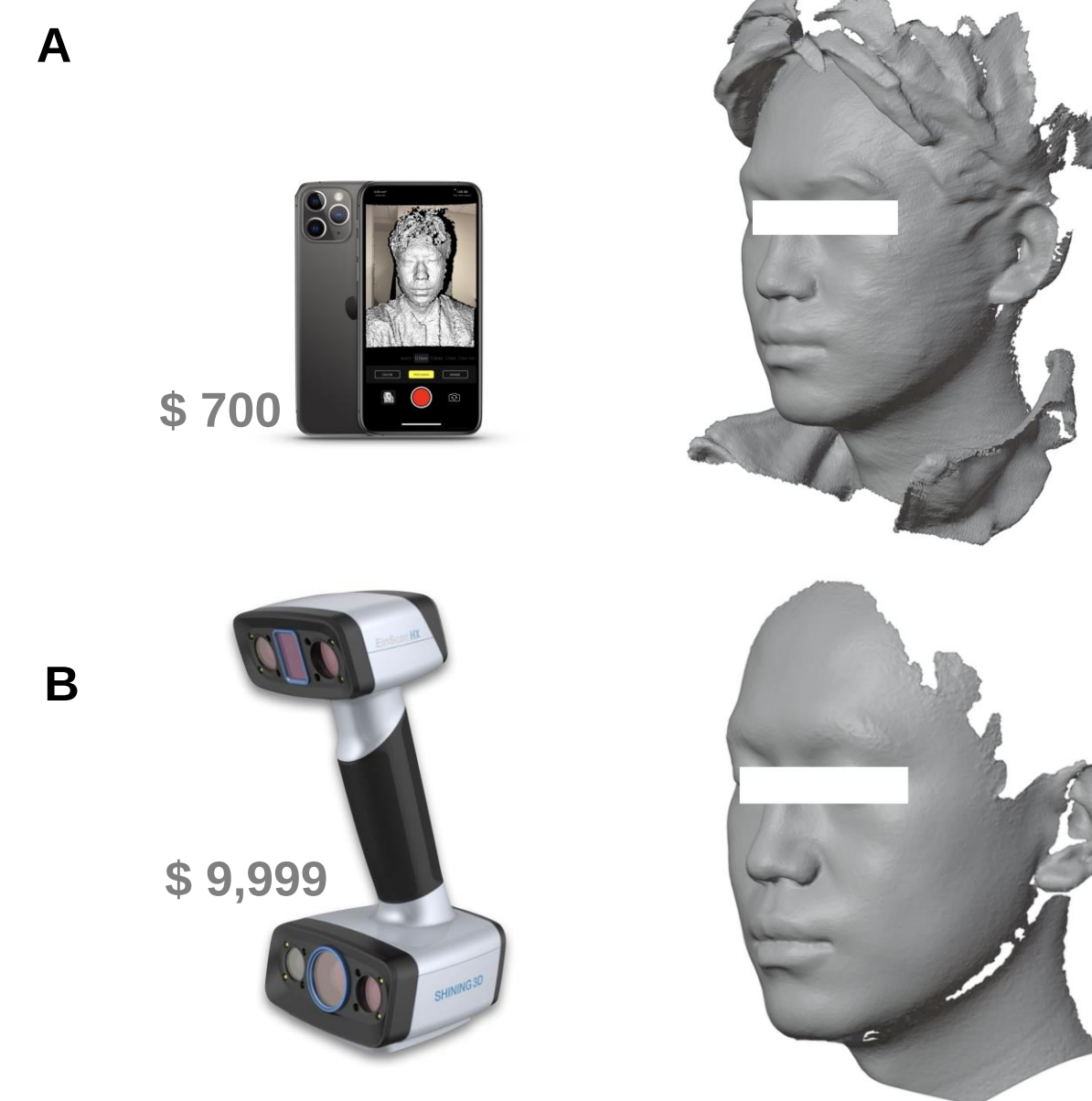


Figure 4. A, Smartphone scanner (iPhone 13 Pro, Apple) and its face scan. B, Industrial scanner (EinScanHX, Shining 3D) and its face scan

RESULTS

Table 1. Trueness of virtual facebow records by two different scanners							
		Smartphone Scanner			Industrial Scanner		
		Mean ± SD	Median	Range	Mean ± SD	Median	Range
3D linear deviation (mm)	Tooth #9	2.18 ± 1.08	2.03	0.49-6.14	1.59 ± 0.95	1.33	0.28-4.86
	Tooth #3	2.51 ± 1.20	2.31	0.42-6.37	1.55 ± 0.98	1.10	0.56-4.08
	Tooth #14	2.65 ± 1.21	2.49	0.14-5.39	1.93 ± 1.13	1.61	0.58-6.46
	Combined	2.45 ± 1.16	2.28	0.35-5.97	1.69 ± 1.02	1.35	0.47-5.13
3D angular deviation	Occlusal plane	1.78 ± 1.10	1.48	0.41-4.39	1.25 ± 0.88	0.79	0.31-3.37

‡Linear mixed model comparing the difference between two groups. *p < 0.05.

Table 2. Precision of virtual facebow records by two different scanners							
		Smartphone Scanner			Industrial Scanner		
		Mean ± SD	Median	Range	Mean ± SD	Median	Range
3D linear deviation (mm)	Tooth #9	1.27 ± 1.23	0.99	0.17-6.25	0.61 ± 1.04	0.25	0.00-4.76
	Tooth #3	1.14 ± 1.10	0.80	0.09-5.86	0.56 ± 0.94	0.26	0.00-4.43
	Tooth #14	1.24 ± 1.12	0.93	0.09-5.84	0.74 ± 1.31	0.31	0.00-6.16
	Combined	1.22 ± 1.15	0.91	0.12-5.98	0.64 ± 1.10	0.27	0.00-5.12
3D angular deviation	Occlusal plane	0.88 ± 0.68	0.68	0.01-2.89	0.51 ± 0.24	0.24	0.01-3.14

‡Linear mixed model comparing the difference between two groups. *p < 0.05.

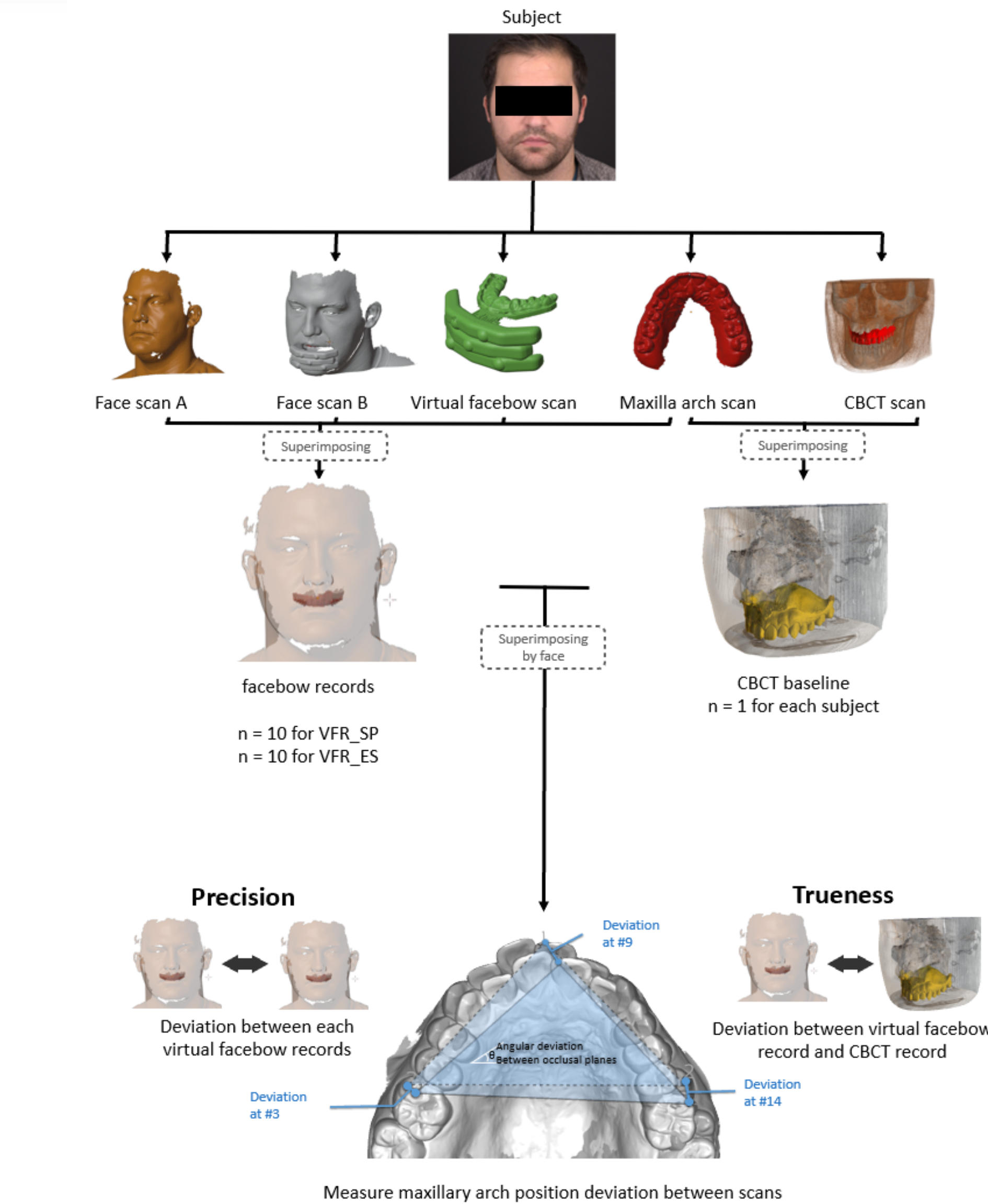


Figure 5. The measurement process. Precision was measured as average deviation within a group of VFRs, while trueness was measured as deviation between virtual facebow record and CBCT scan (baseline).

DISCUSSION

The current study demonstrated that the industrial scanner based virtual facebow records are more accurate than the smartphone-based virtual facebow records. In terms of trueness, the industrial scanner VFR was around 1.69 mm while the smartphone-based VFR was 2.45 mm, the difference between the two was around 0.75 mm. In terms of precision, the accuracy difference between two scanners was around 0.6 mm.

Is this accuracy difference clinically significant? Looking at research by Choi et al, their study demonstrated that the average precision of conventional facebow records was around 3 mm. Compared to that study, both smartphone 3D scanner and industrial scanner provide better accuracy. Considering the much lower cost of a smartphone-based scanner, the authors would recommend dentists use a smartphone to capture face scans and to obtain virtual facebow records.

Conclusion

The virtual facebow records captured by an industrial scanner are more accurate than the smartphone-based records. However, the difference was small.

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