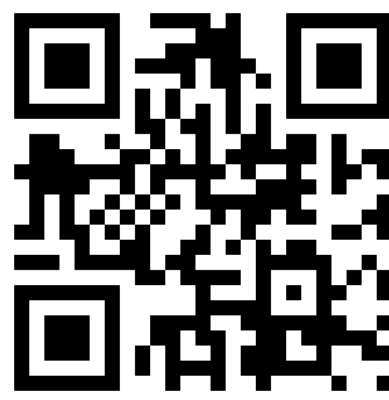# Wound healing by plaque control in clinically validated robot programmes

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Objectives:

Complex early wound healing after **oral implantation,** supported by different oral hygiene methodologies, was assessed in three groups per 12 subjects each for 14 days. Therefore, these results of plaque reduction were adapted to clinically validated robot programmes of plaque control by manual toothbrushes to replace time-consuming clinical testing by robot tests of hygiene efficacy. Full mouth planimetric plaque assessment using clinPPI will be mirrored by toothbrushing robot programme utilizing replicated human teeth and simulating dental implant placements in anterior and posterior dentition in artificial oral cavity **AOC.**

Material and Methods:

The three-arm randomized study was ethic... (UW/H EK192/2022). Same hygiene products and brushing techniques were used in the clinical arm as well as in the robot arm. Seven brushing cycles per group were conducted on the robot dentition covered with organic plaque simulation (Pepin et al. 2020). Clinical groups were duplicated for the robot toothbrushing test. The AOC was used on the robot constantly rinsing a slurry during brushing process using a peristaltic pump system (slurry dilution ratio of 2:1).

Group A OROFAN® Gel contains ChitoClear and 3 other bio-polymers, executes at mucosal cells a virus barrier for up to 16h, Sensodyne manual toothbrush with flexible neck; **Group B** Sensodyne manual toothbrush with flexible neck, ProEnamel extra fresh; **Group C** Sensodyne Multicare Expert toothbrush with fixed neck, ProEnamel extra fresh.

Agreement Rates were calculated to compare planimetrical plaque values in-vivo versus in-vitro. Automated Plaque Planimetry **APP** revealed the percentage of plaque removal, and **clinPPI** values were adapted to this percentages.

Results:

Validation was documented with agreement rate >80.00 %. The values in all 3 groups at the end of study varied from buccal smooth surfaces **(99-100%),** lingual smooth surfaces **(83-88%),** buccal high risk areas **(81-85%)** and lingual high risk areas **(60-69%, Non validated)**.

The error bar diagrams illustrate the mean plaque reduction with 95% confidence intervals for both the clinical (clinPPI) and robot (APP) measurements across all oral surface regions. Notably, APP consistently showed lower plaque scores and narrower confidence intervals in the lingual high-risk areas compared to clinPPI, indicating both higher cleaning efficacy and reduced variability. These findings support the superior reproducibility and precision of the robot method, especially in anatomically complex or hard-to-reach regions, where clinical manual techniques may be more inconsistent. This supports the clinical validation of the APP method, as its high concordance with clinPPI data—particularly in vestibular areas. Its consistent performance in high-risk regions demonstrate its reliability for evaluating oral hygiene efficacy in a standardized, reproducible manner.

Conclusions:

Clinically validated planimetrical robot plaque assessment offers a reliable methodology to determine the best hygiene protocol after oral implantation. The findings demonstrate the effectiveness of the robot brushing protocol and its high agreement with clinical data, despite the limitations of replicating true anatomical conditions in vitro. Notable benefits of the robot programme were observed especially in anatomically challenging areas, where reduced variability enhances the ability to discriminate differences between different products. Therefore, robot testing contributes to quickly evaluate the plaque control effectivity in new oral care products for special patient needs.

Fig. 1: Tested oral hygiene products: MTB **A**: Sensodyne- Bodyguard with flexible neck; **B**: Sensodyne- Multicare Expert; **C:** oral care gel OROFAN® Gel; **D:** dentifrice ProEnamel extra fresh.

Fig. 2: KaVo (Biberach, Germany) tooth model with synthetic teeth; teeth 32, 44 and 47 were left out, the alveoli were sealed with a silicone to simulate a post implantation situation. In comparison, a clinical picture involving an implant placed in a mandibular edentulous space.
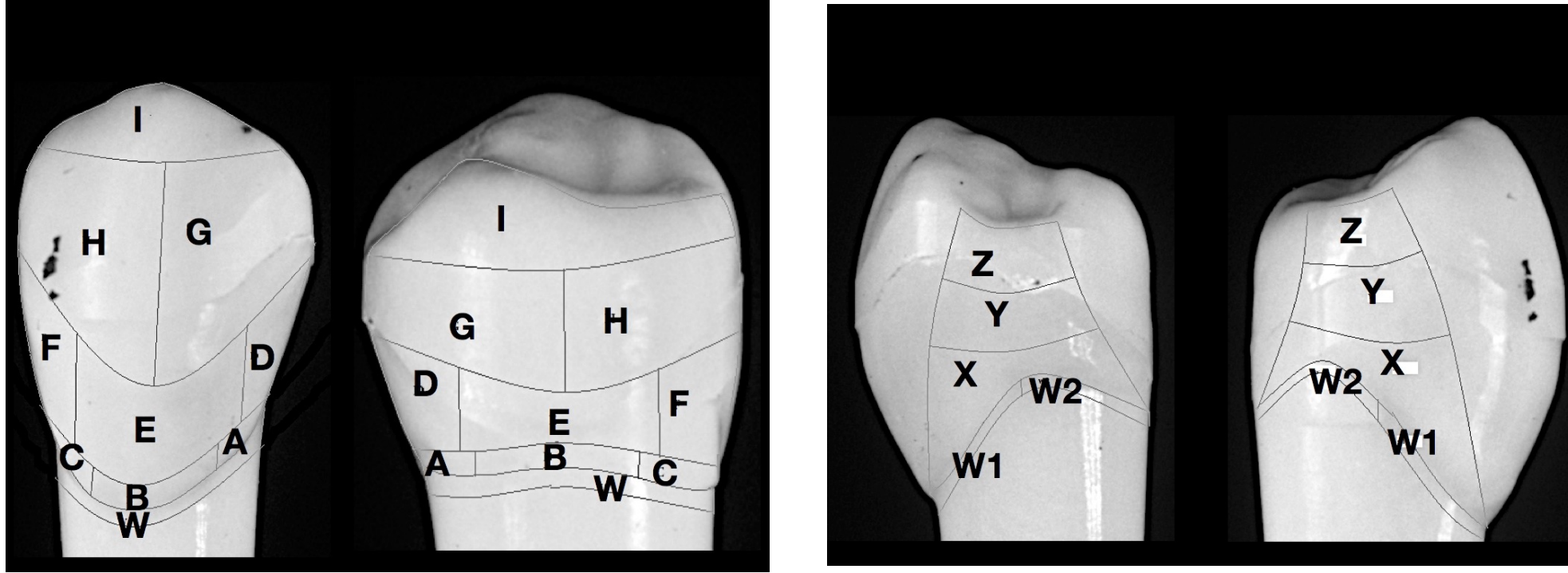
Fig.3: Planimetrical fields at tooth crowns and roots of smooth surfaces (left) and mesially and distally in-between the teeth (right) (Gaengler et al., 2013).
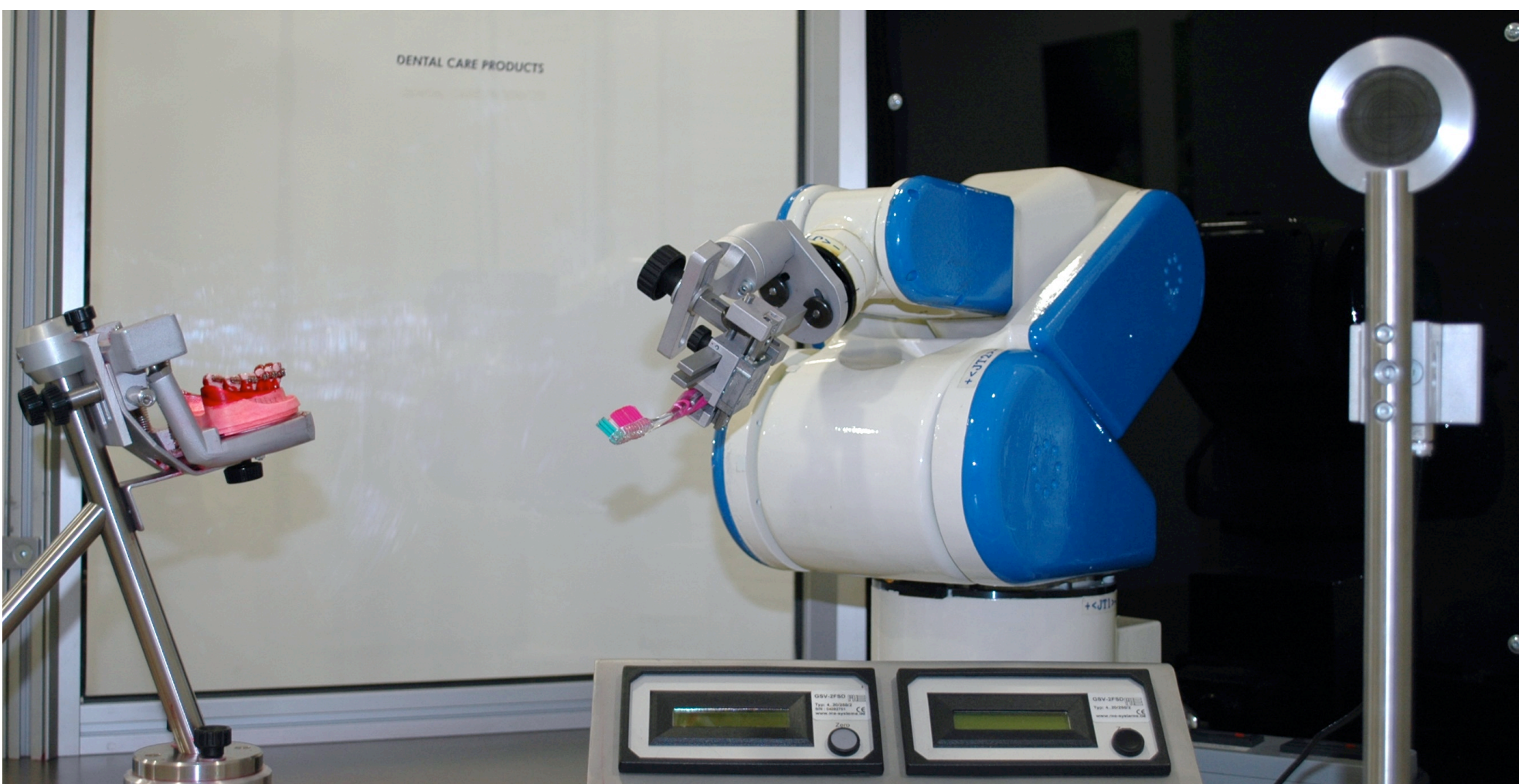
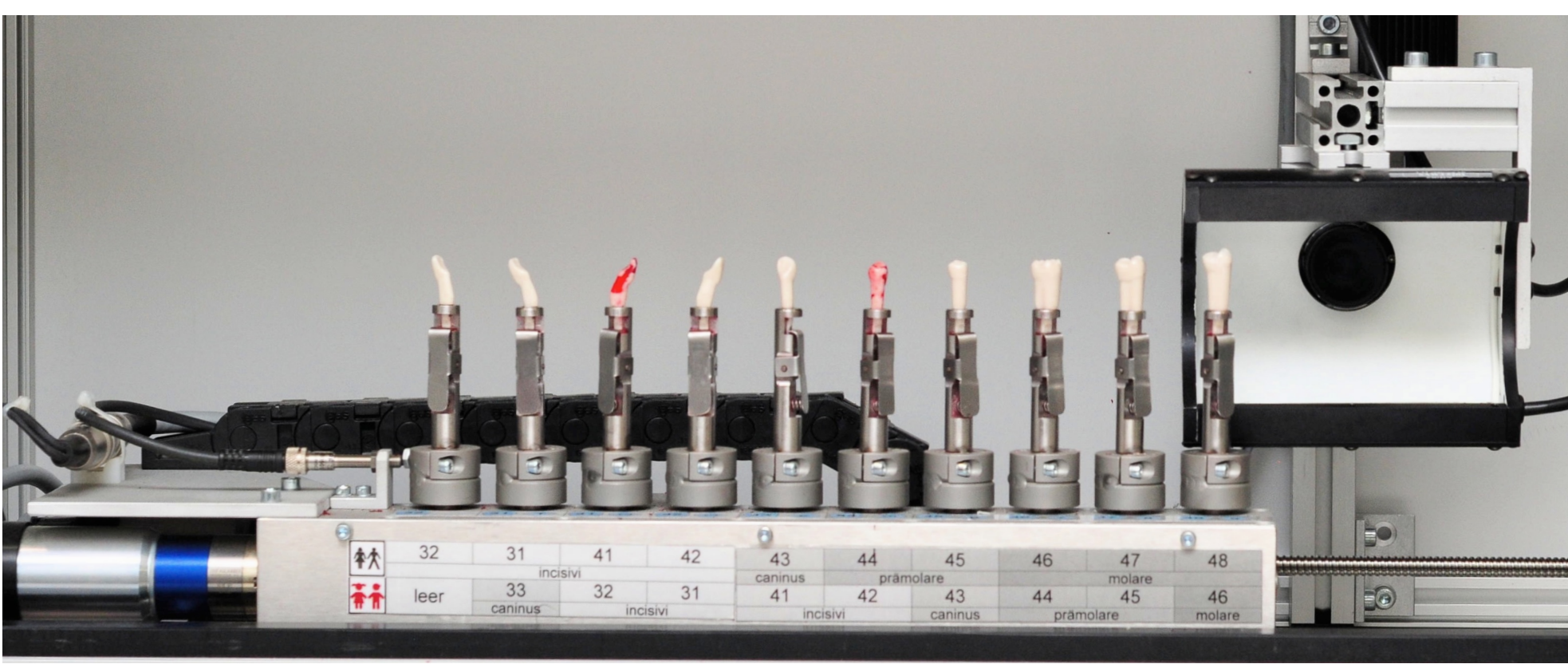**Fig. 4:** Kawasaki robot FS 02N; stained model placed in a fixture

Fig. 5: Automated Plaque Planimetry (APP); teeth covered with organic plaque simulation after brushing

group A, day 7:					group A, day 14:				
	Means		**Agreement rates**			**Means**		**Agreement rates**	
	clinPPI_A	APP_A				clinPPI_A	APP_A		
ALL_VES	8.46	8.59	100.74		**ALL_VES**	8.76	8.59	99.07	
ALL_LIN	8.74	6.74	88.93		**ALL_LIN**	8.84	6.74	88.37	
ABCDF_VES	6.17	4.61	84.42		**ABCDF_VES**	6.49	4.61	81.23	
ABCDF_LIN	6.57	3.48	69.04		**ABCDF_LIN**	6.57	3.48	69.08	

group B, day 7:					group B, day 14:				
	Means		**Agreement rates**			**Means**		**Agreement rates**	
	clinPPI_B	APP_B				clinPPI_B	APP_B		
ALL_VES	7.50	8.29	104.36		**ALL_VES**	7.68	8.29	103.38	
ALL_LIN	8.44	6.09	86.94		**ALL_LIN**	9.12	6.09	83.19	
ABCDF_VES	5.71	4.49	87.84		**ABCDF_VES**	5.91	4.49	85.78	
ABCDF_LIN	6.49	3.02	65.37		**ABCDF_LIN**	6.99	3.02	60.32	

group C, day 7:					group C, day 14:				
	Means		**Agreement rates**			**Means**		**Agreement rates**	
	clinPPI_C	APP_C				clinPPI_C	APP_C		
ALL_VES	8.26	8.55	101.62		**ALL_VES**	8.47	8.55	100.47	
ALL_LIN	8.38	6.19	87.84		**ALL_LIN**	8.53	6.19	87.02	
ABCDF_VES	6.05	4.69	86.48		**ABCDF_VES**	6.30	4.69	83.93	
ABCDF_LIN	6.35	3.22	68.75		**ABCDF_LIN**	6.45	3.22	67.72	

Tab. 1: Calculated Means and Agreement rates from the clinical (day 7 left and day 14 right) and robot data for vestibular surfaces (ALL_VES), lingual surfaces (ALL_LIN), as well as for the vestibular (ABCDF_VES) and lingual (ABCDF_LIN) high-risk fields
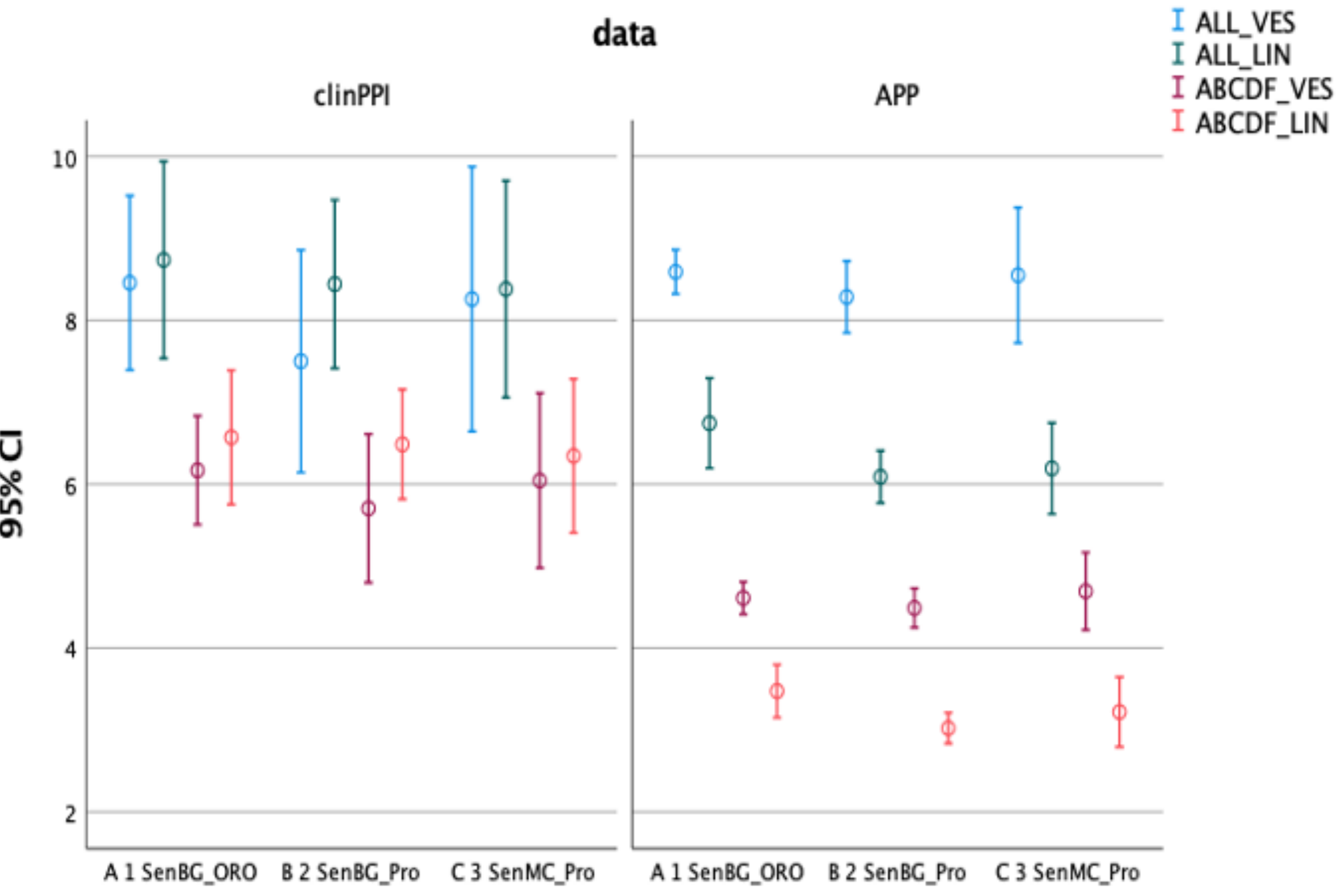
Tab. 2: Error bars of mean plaque reduction of clinPPI fields from postbrushing DAY 14 and APP for all groups with confidence intervals (95%). Number of observatio per each toothbrush: n=7

Tab. 3: Error bars of mean plaque reduction of clinPPI fields from postbrushing DAY 14 and APP for all groups with confidence intervals (95%). Number of observatio per each toothbrush: n=7

References:

Pepin H, Lang T, Weich K, Gaengler P (2020). Validation report, Clinical validaIon of Organic Plaque SimulaIon (PG Plaque) in Robot Toothbrushing Tests. ORMED, Germany: Journal of Dental Research, 2020, Vol. 99, Spec. Issue B Abstract No. 3075

Lang T, Staufer S, Jennes B, und Gaengler P. 2014. Clinical validation of robot simulation of toothbrushing - comparative plaque removal efficacy. BMC Oral Health 14:82.