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Clinically simulated brushing-vibrating plaque control by lamellar full-mouth devices

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Objectives:

All toothbrushing methods have advantages and disadvantages. Therefore, robot tests of alternative biophysical lamellar brushing actions are needed. The aim was (i) to test two prototypes (BLBR, Grünwald, Germany) with a clinically validated robot programme, (ii) to introduce the new occlusal Planimetrical Plaque Index oPPI and (iii) to compare the efficacy of the full-mouth devices with Philips Sonicare powered toothbrush (Drachten, Netherlands).

Material and Methods:

After pretesting different Shore hardness A materials, vibration modes and intermediate dentifrice foams (Aero - containing sodium fluoride/ nitrogen, Toyo – containing amine fluoride/nitrogen, BLBR, Grünwald) the SHA was set to 43 and the vibration to 140 Hz. Prototype RED 2 employed indirect, prototype RED 3 direct vibration transfer from handle to lamellar full-mouth brush. Occlusal brushing force was 7.5 N, lateral movement 6.0 cm, vertical movement 2.0 cm. Ten replicated human KaVo-teeth in anatomic position were coated with clinically validated plaque simulation (PG plaque, Pepin et al. 2020). Sixty seconds brushing was followed by computer-assisted planimetrical plaque assessment at 24 coronal fields (PPI), 2 occlusal fields at premolars and 4 occlusal fields at molars including the wisdom teeth (oPPI). For evaluation 4 sites per tooth with 4 risk areas (XY fields in-between, ABCDF fields next to gum line) were defined. The Philips Diamond Clean/Sensitive Head brushed the same teeth, brushing force 1.5 N, 120 s, strictly according to recommendations.
Data underwent statistical analysis after the Kolmogorov-Smirnov-test of 12 variables for normal distribution. H0 of normality was accepted for the PPI values and clearly rejected for oPPI values. Therefore, the independent two samples t-test (PPI) and the non-parametric U-test (oPPI) were applied.

Results:

Prototype RED 3 was superior to Prototype RED 2 and Philips Sonicare PTB in all buccal coronal fields at smooth surfaces (81.7 – 92.0 % plaque removal) and risk areas in-between teeth and next to the gum line (32.5 – 59.4 % plaque removal), significantly different ($p<=0.001$ – $p<=0.05$) from Philips Sonicare PTB. However, differences in occlusal plaque removal were non-significant after Bonferroni correction. Analysis of single teeth revealed optimal plaque control by Prototype RED 3 around all incisors, canines, premolars and molars.

Conclusions:

The unique bio-physical brushing-vibrating mechanism of action - of a powered lamellar toothbrush prototype is promising for effective plaque control.

The MOA is supported by a special fluoride containing dentifrice foam.

The new Occlusal Planimetrical Plaque Index oPPI is relevant for biofilm disclosure.

References:

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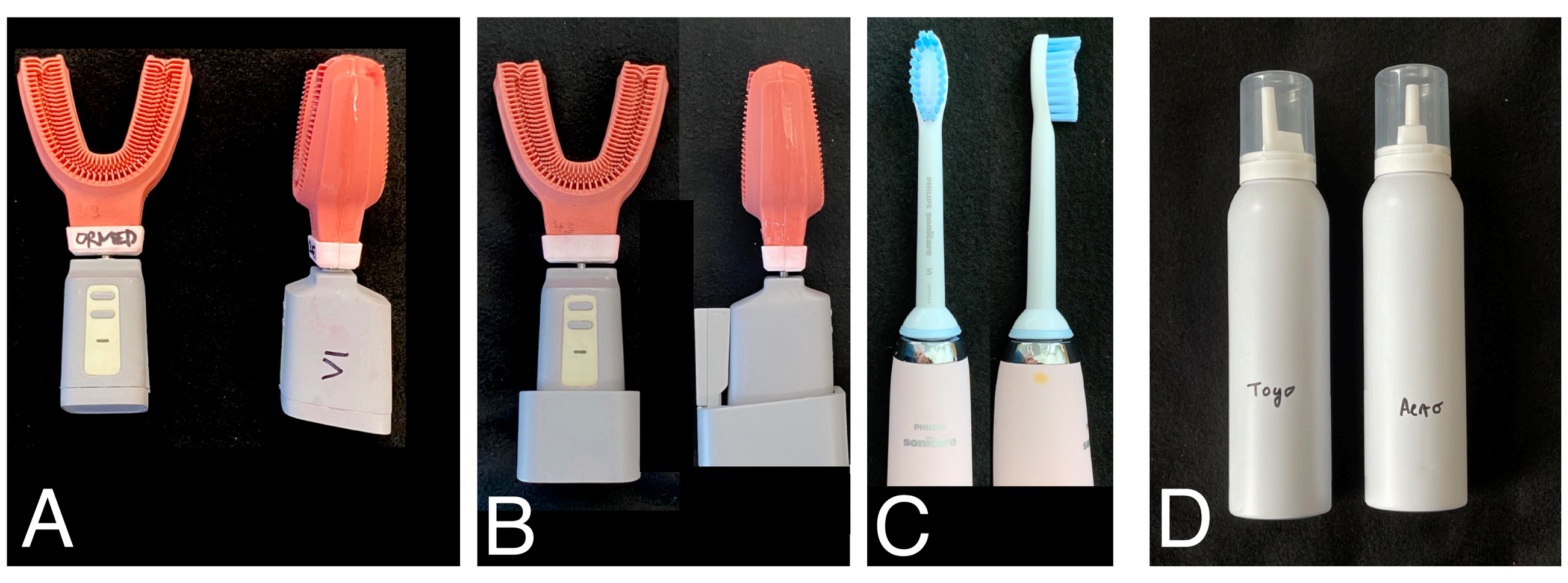

Fig. 1:
A - Blitzbrush Prototype BLBR RED 3 SHA 43 140Hz, **fixed** brush head,
B - Blitzbrush Prototype Version RED 2, SHA 43, 140 Hz, **removable** brush head
C - Philips Sonicare Diamond Clean with Sensitive Head
D - Dentifrice foams **Toyo** and **Aero**

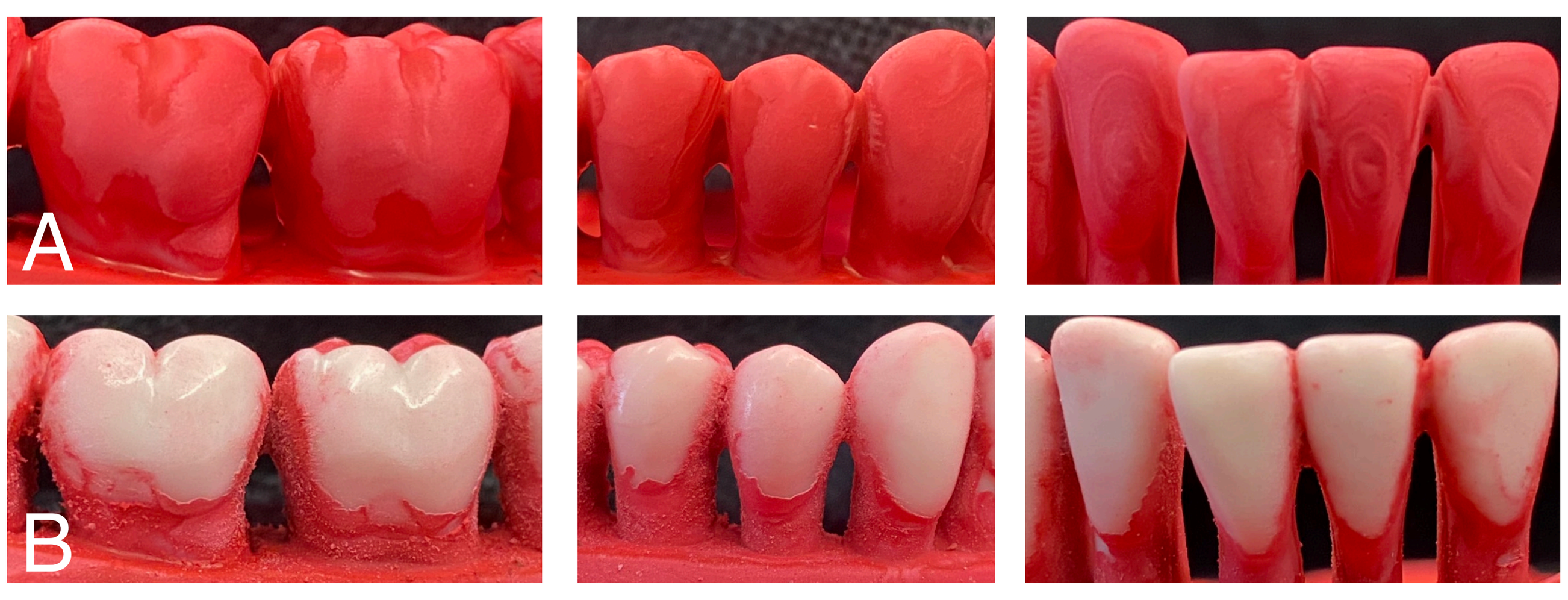

Fig. 2:
A - Stained organic plaque simulation
B - Post brushing examples (Pepin et al. 2020)

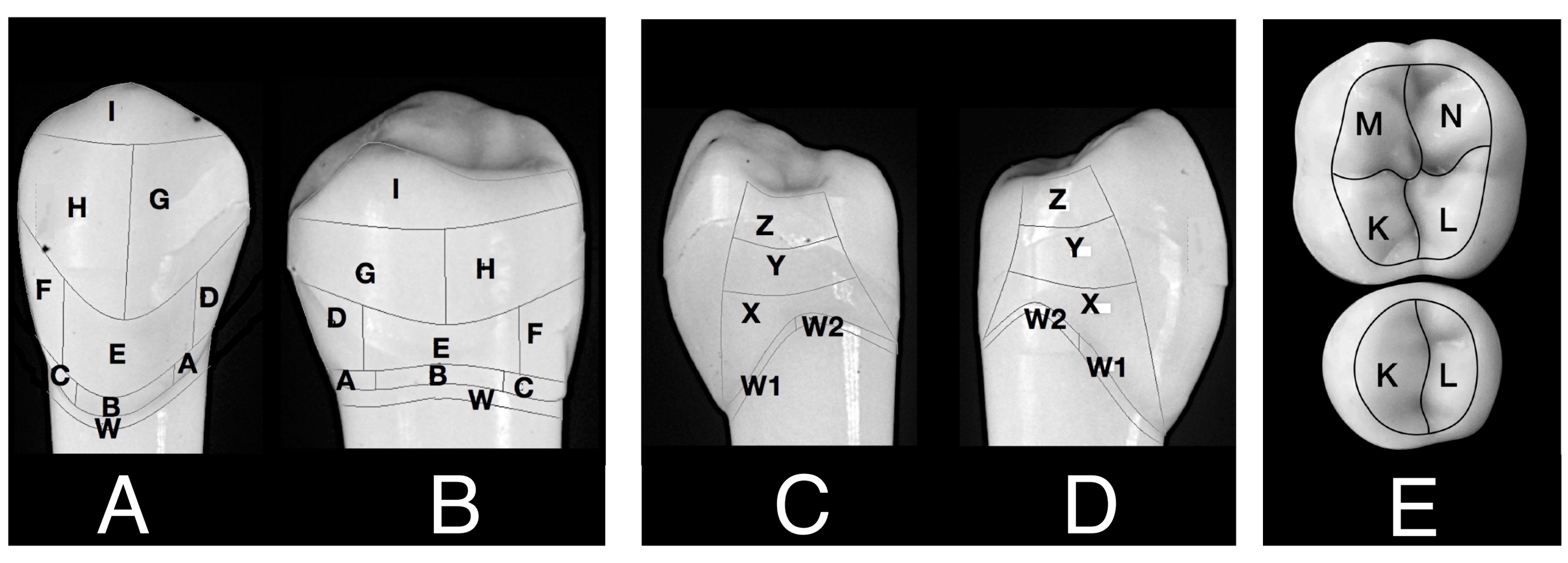

Fig. 3:
Planimetrical fields at tooth crowns and roots of smooth surfaces (A,B) and mesially (C) and distally (D) in-between the teeth for plaque assessment in percentages per field, per risk area or per tooth site with automated plaque planimetry APP according to the Planimetrical Plaque Index PPI (Lang et al., 2011); oPPI at molars, occlusal planimetrical fields K and L medially and M and N distally (E); below: oPPI at premolars, planimetrical fields K buccally and L lingually (E).

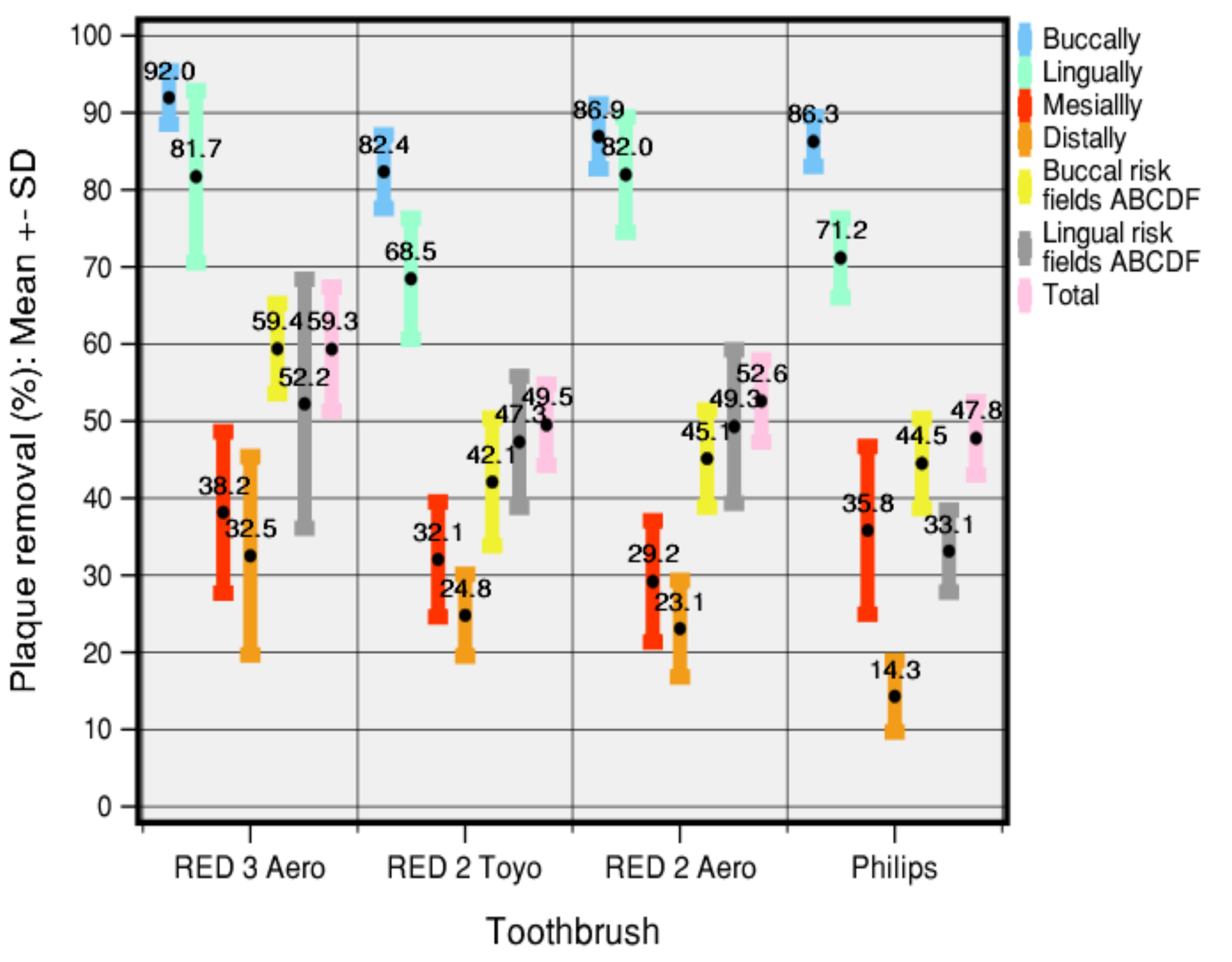

Fig. 4 : Error bars of plaque removal buccally (towards the cheek), lingually (towards the tongue), mesially (anterior, in-between the teeth), distally (posterior, in-between the teeth), at buccal and lingual risk fields ABCDF (next to the gum line) and total for the four tested toothbrushes

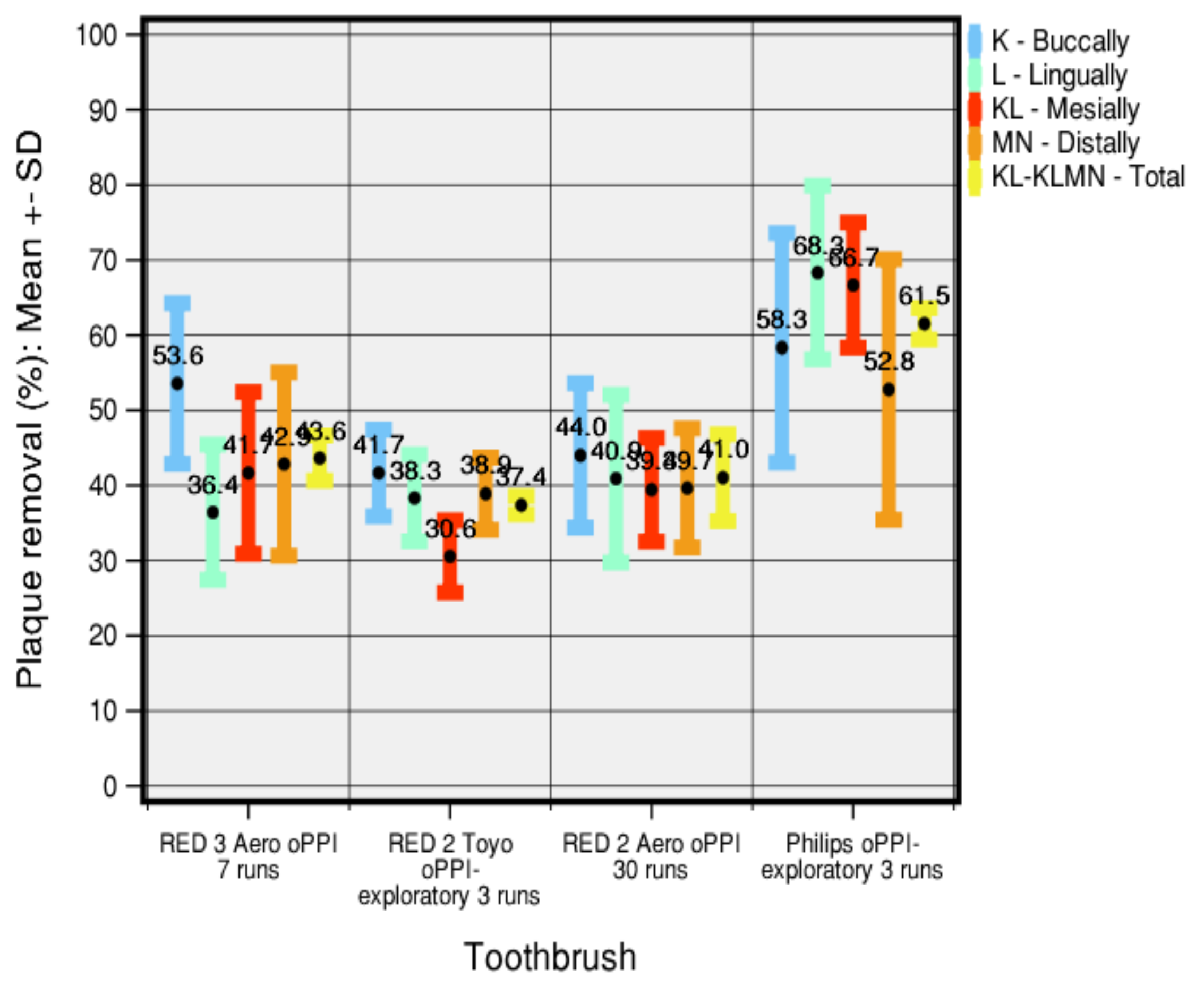

Fig. 5 : Error bars of plaque removal at occlusal surfaces with planimetrical fields KL at premolars and KLMN at molars for the four tested toothbrushes

Tab. 1: t-test of cleaning efficacy (% plaque removal): Multiple contrasts of the four toothbrushes
t = test statistic of t-test; df = degrees of freedom; p = significance value
* significant ($p \leq 0.05$)
** very significant ($p \leq 0.01$)
*** highly significant ($p <= 0.001$)
yellow marking = not significant using Bonferroni correction

Contrast	Tooth surface	t-Test			
		t	df	p	Mean
RED 3 Aero vs. RED 2 Toyo	Buccally	4.997***	35	0.000	9.59
	Lingually	3.703***	35	0.001	13.25
	Mesially	1.807	35	0.079	6.11
	Distally	1.557	6.483	0.167	7.72
	ABCDF buccally	5.202***	35	0.000	17.29
	ABCDF lingually	0.786	6.794	0.458	4.95
	Total	3.993***	35	0.000	9.82
RED 3 Aero vs. RED 2 Aero	Buccally	2.918**	35	0.006	5.02
	Lingually	-0.076	35	0.940	-0.26
	Mesially	2.553*	35	0.015	8.97
	Distally	1.891	6.677	0.102	9.46
	ABCDF buccally	5.452***	35	0.000	14.26
	ABCDF lingually	0.623	35	0.537	2.95
	Total	2.728**	35	0.010	6.73
RED 3 Aero vs. Philips	Buccally	4.140***	35	0.000	5.69
	Lingually	2.437*	6.604	0.047	10.55
	Mesially	0.514	35	0.611	2.33
	Distally	3.689**	6.377	0.009	18.23
	ABCDF buccally	6.044***	35	0.000	14.89
	ABCDF lingually	3.092*	6.306	0.020	19.12
	Total	3.651**	7.014	0.008	11.56

Tab. 2: Examples of single tooth analysis (teeth 31-41 and teeth 47, 48)

Tooth	Tooth surface	Toothbrush			
		RED 3 Aero	RED 2 Toyo	RED 2 Aero	Philips
31	Buccal	98.68	94.96	94.96	87.93
	Lingual	90.29	86.76	94.75	88.08
	Mesial	43.32	59.97	42.85	38.86
	Distal	45.03	33.13	35.24	23.81
	ABCDF Buccally	62.57	45.42	41.40	48.47
	ABCDF Lingually	60.42	80.92	67.89	31.41
	Total	66.72	66.86	62.85	53.09
32	Buccal	95.67	91.43	95.83	75.05
	Lingual	90.18	93.93	93.45	52.29
	Mesial	57.45	36.23	45.80	36.12
	Distal	17.15	7.17	12.11	3.00
	ABCDF Buccally	60.05	41.31	43.75	50.82
	ABCDF Lingually	62.44	63.58	62.86	9.54
	Total	63.82	55.61	58.97	37.80
41	Buccal	97.85	93.84	93.49	79.87
	Lingual	77.56	74.72	86.91	77.38
	Mesial	46.87	40.91	36.72	16.46
	Distal	39.75	13.41	24.92	17.98
	ABCDF Buccally	58.14	35.87	28.77	40.83
	ABCDF Lingually	53.86	48.22	54.84	29.58
	Total	62.34	51.16	54.83	43.69

Tooth	Tooth surface	Toothbrush			
		RED 3 Aero	RED 2 Toyo	RED 2 Aero	Philips
47	Buccal	90.03	81.90	83.88	90.93
	Lingual	83.48	49.91	69.16	69.66
	Mesial	23.25	13.22	13.99	36.97
	Distal	14.59	12.36	12.35	7.14
	ABCDF Buccally	71.92	51.97	66.76	38.07
	ABCDF Lingually	30.89	20.27	26.24	23.61
	Total	52.36	38.27	45.40	44.40
	K - Buccally	32.14	25.00	31.67	75.00
	L - Lingually	25.00	25.00	30.00	58.33
	KL - Mesially	28.57	25.00	30.83	66.67
	MN - Distally	46.43	33.33	32.50	41.67
48	Buccal	93.89	91.85	93.79	87.74
	Lingual	81.99	69.82	82.18	57.35
	Mesial	31.93	25.53	28.64	41.37
	Distal	87.75	81.79	74.13	7.29
	ABCDF Buccally	72.32	64.40	66.44	37.13
	ABCDF Lingually	63.97	54.81	54.72	52.19
	Total	71.98	64.70	66.65	47.18
	K - Buccally	60.71	58.33	68.33	58.33
	L - Lingually	53.57	25.00	48.33	58.33
	KL - Mesially	57.14	41.67	58.33	58.33
	MN - Distally	50.00	58.33	56.67	50.00