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Robot Test of Cleaning Efficacy by Plaque Planimetry

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Aims

- Toothbrushing reduces plaque levels and minimises the risk of plaque-associated diseases such as dental caries, gingivitis and periodontitis[1,2]
- This *in vitro* study compared cleaning efficacy at low brushing force of five marketed toothbrushes with a unique handle neck flexibility design compared to a control

Methods

- Five marketed toothbrushes, with a flexible ball joint bend in the neck and differing bristle arrangement, plus a reference (GSK Consumer Healthcare, Brentford, UK), were tested using a clinically validated, comparative robot test[3] to examine *in-vitro* brush efficacy
  - KaVo™ human teeth replications were used: four incisors, one canine, two premolars, three molars in anatomic positions, coated in clinically validated, simulated plaque
  - Seven runs each of horizontal, seven rotating and seven vertical movements at 2.5 N

Toothbrush A (soft brush)

Toothbrush B (medium brush)

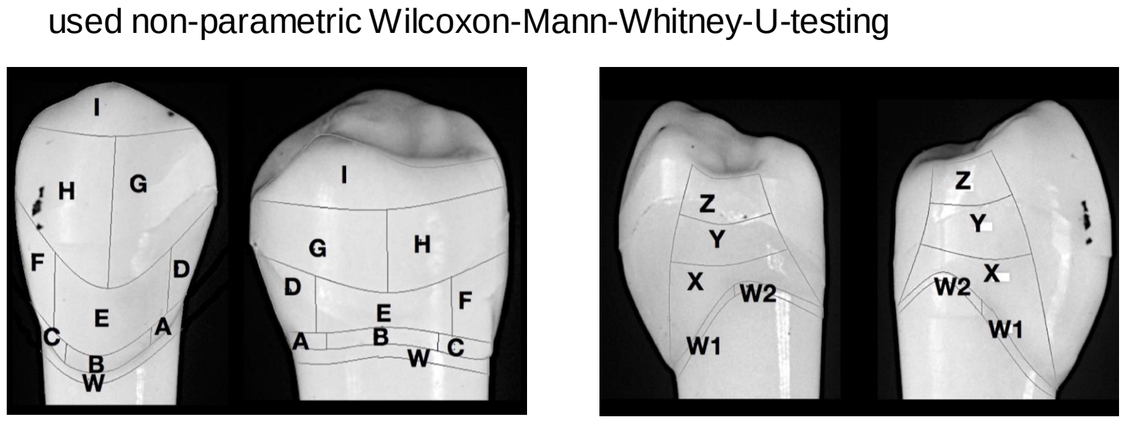
Toothbrush C (soft brush)

Toothbrush D (soft brush)

Toothbrush E (soft brush)

Reference (soft, uniform bristles)

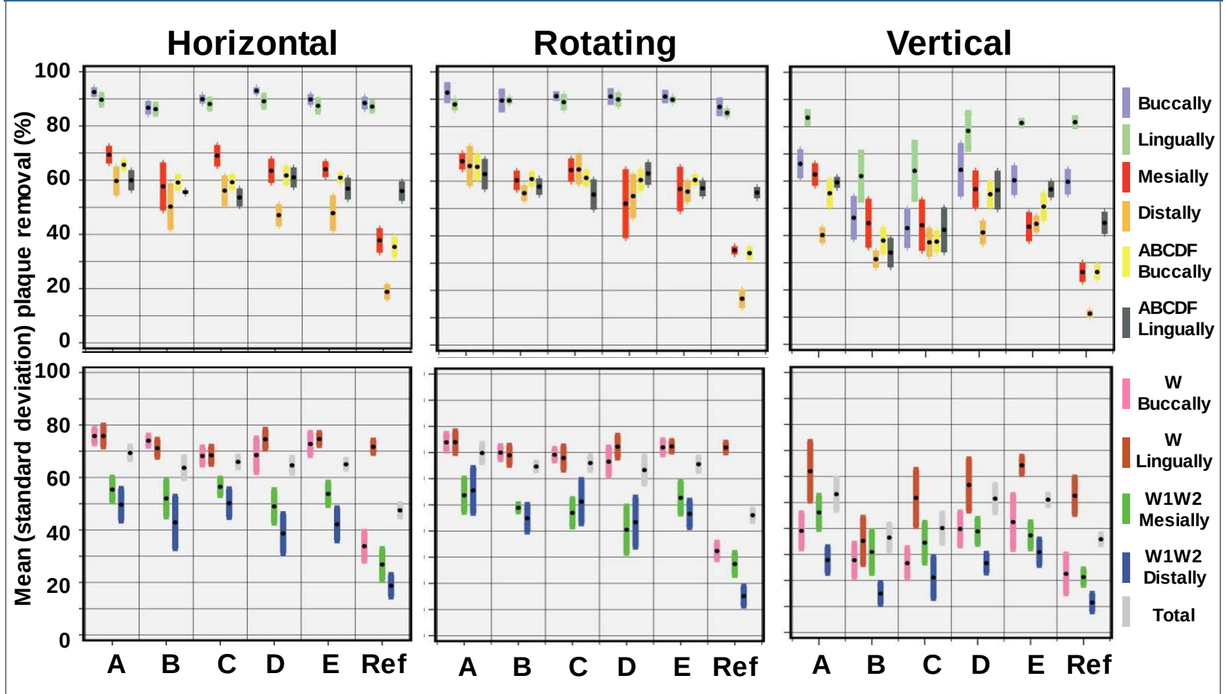
- Evaluation of plaque removal carried out using automated plaque planimetry
  - 30 planimetrical fields per tooth representing buccal, lingual and proximal sites of tooth crowns and exposed tooth roots (Gumline: ABCDF; Interproximal: DF; Crown smooth surface: EGHI; In-between teeth mesially and distally: XYZ; Root: buccally and lingually: W, proximally: W1W2; Proximal root: W1W2) encompassing 12 risk areas
  - Mean simulated plaque reduction was compared to evaluate cleaning efficacy at:
    - All buccal/lingual tooth sites (A–I); at risk fields near gum line and approximally between teeth (ABCDF fields at buccal/lingual sites); all mesial/distal sites (proximal in-between teeth); root buccally/lingually/mesially/distally; all sites (total 30 fields per tooth)
  - The Kolmogorov-Smirnov-test was applied to test tooth surfaces variables; null hypothesis of normality was rejected therefore analysis used non-parametric Wilcoxon-Mann-Whitney-U-testing



Planimetrical fields at tooth crowns and roots of smooth surfaces (left) and mesially and distally in-between the teeth (right) for plaque assessment in percent per field, per risk area or per tooth site with automated plaque planimetry APP[3]

Results

Plaque removal efficacy (% mean and standard deviation)



Statistical analysis of cleaning efficacy (% plaque removal)

	A					B				C			D		E
	B	C	D	E	Ref	C	D	E	Ref	D	E	Ref	E	Ref	Ref
Buccally	HV	HV		H	HR	H	HV	HV	V	HV	V	RV	H	HR	R
W Buccally	RV	HRV	HR		HRV	H	V	V	HR	V	HRV	HR		HV	HRV
ABCDF Buccally	HV	HV	H	HR	HRV		HV	V	HRV	V	V	HRV		HV	HRV
Lingually	HV	V			HR		V	V	RV	V	V	RV		R	R
W Lingually	V	HR			H	V	V	V	V	H	HV	H			V
ABCDF Lingually	HV	HRV			RV		RV	V	V	HRV	V			V	V
Mesially	HRV	V	HR	HRV	HRV	H			HRV	HV	H	HRV	V	HV	HRV
W/W2 Mesially	RV	V	RV	V	HRV		R		HRV	H		HRV		HV	HRV
Distally	HRV		HR	HRV	HRV	RV	V	V	HRV	HR	HRV	HRV		HV	HRV
W1/W2 Distally	RV		HR		HRV		V	V	HR	H	HV	HRV		HV	HRV
Total	HRV	HRV	HR	HR	HRV		V	V	HR	HV	V	HR		HV	HRV

Toothbrush with statistically significant higher ($p<0.05$) percentage plaque removal is shown by corresponding colour of brushing movement (Black or Orange) where **H:** Horizontal; **R:** Rotating; **V:** Vertical movements

ABCDF: Risk fields near gum line and interproximal; **W:** Tooth root sites;
Total: Total mean plaque reduction over all tooth sites;

- Performance order of the toothbrushes was: Toothbrush A>Toothbrush D>Toothbrush E>Toothbrush C=Toothbrush B>Reference
- Test toothbrushes were statistically superior ($p<0.05$) to the Reference brush overall (total) in horizontal movements with 4/5 toothbrushes in rotating and 3/5 toothbrushes in vertical movements
- Superior brushing efficacy was at a lower level with vertical movements than with rotating or horizontal movements
- Single tooth analysis showed optimal simulated plaque removal at incisors (up to 99.75% >canines>premolars>molars up to 45.72%)
- At 2.5 N, handle neck flexibility was 75% of capacity according to force measurement

Conclusions

- Plaque control is postulated to differ with different movements due to the toothbrush ball joint bend supporting horizontal/rotating flexible brushing movements, with vertical brushing limiting the force transfer from the neck to the head
- Based on this *in vitro* model, brushing efficacy of the test toothbrushes with handle neck flexibility can be interpreted as optimal plaque control at all risk areas and their single planimetrical fields, contributing to good oral hygiene

References

1) Fejerskov I. *Dental caries: The disease and its clinical management.* Blackwell Munksgaard. John Wiley & Sons, Ltd, 2015;
2) Löe H. Int Dent J 2000; 50:129–39; 3) Lang T, Staufer S, Jennes B, Gaengler P. BMC Oral Health, 2015, 4;14:82

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